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ABSTRACT

The federal government's budgeting process for allocating resources to research and development (R&D) is described. The report includes: (1) a review of the genesis of the FY 1978 budget; (2) a brief look at the overall budgets for FY 1978; (3) a description of the policies underlying the R&D budgets for FY 1978; (4) a discussion of the future outlook for R&D budgets; (5) a proposal for how R&D budgets should be made; and (6) a picture of the workings of Congress as they relate to R&D budgeting. (BB)

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Research and Development in the Federal Budget: FY 1978

Willis H. Shapley
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Herbert Roback

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Research and Development in the Federal Budget

FY 1978

A Report
prepared for the Executive Officer
and the AAAS Committee on
Science and Public Policy

by WILLIS H. SHAPLEY
DON I. PHILLIPS
HERBERT ROBACK

American Association for the Advancement of Science
Washington, D.C.

The AAAS Board of Directors, in accordance with Association policy, has approved publication of this study as a contribution to the understanding of an important process. The interpretations and conclusions are those of the authors and do not purport to represent the views of the Board or the Council of the Association.

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Foreword

The federal government has a decisive role in influencing the rate and the mix of scientific research and development in the United States. Shifts in policy goals and priorities invariably have a reflex upon industrial and academic as well as governmental R&D. They affect investment choices, manpower training, product innovation, and rates of employment and underemployment in technology-intensive industries. Therefore, budget decisions and federal budgeting and planning procedures – in both the Congress and the Administration – bear watching and interpretation by all who are concerned with the advancement of science, the continuity of research, rates of innovation, and the direct and indirect roles of R&D in the national economy.

Myths and misconceptions abound regarding the federal funding of research and development. AAAS, in sponsoring and publishing this study, is not only interested in tracking the content and policies of the federal budget but in shedding needed light upon the dimly seen decision-making process which produces outcomes. Last year we undertook the first of these studies with the principal aim of dispelling some of the general confusion about how the system works. Much of its thrust, though not all, was on the Executive Budget process. This year's study takes a closer look at the Congressional process because Congress has the last word on priorities and funds. The paper by Herbert Roback serves to reveal the real world from the viewpoint of one who has lived in it and with it, and it leaves us with issues which need critical examination.

The governmental budgeting system for R&D is a creature of prehistory to a great extent: The basic processes for estimating requirements and reaching decisions have been in place for a long time. As R&D grew in the past several decades from a small claimant on the budget to a very formidable claimant, no quarter was conceded to its "special" case, real or imaginary. The same uncertainty goes with funding R&D as accompanies all other "discretionary" activities and functions of government, even though the nature of R&D is that it possesses uncertainties of its own which do not accord with the immu-

table cycles of budgetary planning and control. Is it conceivable that new kinds of procedures and arrangements can be developed which, at one and the same time, recognize the long lead times that are built into R&D, yet respond to the demands for controllability which a workable budgeting process must have?

Willis Shapley, from the perspectives of experience both in the Bureau of the Budget and later at the policy level in a major federal R&D agency, has written a provocative chapter for this report in which he proposes such new arrangements. That chapter, standing alone, makes the whole study worthwhile.

What needs to be said is that the Association, with the publication of this study, is now twice-indebted to Willis Shapley. As the principal author of these successive reports, he has delivered results above and beyond our hopes. What remains is to discover that this venture by AAAS is accomplishing what was intended: to enlarge and enrich the dialogue among government, the research community, industry, and scholars of science policy concerning the quality and effectiveness of decision-making.

William D. Carey
Executive Officer
American Association for the Advancement of Science

Acknowledgments

Again this year, I would like to express my appreciation to the Committee on Science and Public Policy, whose members are listed below, for its sponsorship of this report and their guidance in its planning and preparation, with special thanks to Chairman John M. Logsdon, and to Dr. T. Dixon Long, Chairman of the Subcommittee overseeing the project. The AAAS was fortunate indeed to have Mr. Herbert Roback agree to draw on his long experience on Capitol Hill to write the discerning account of the Congressional role in R&D budgeting in Chapter 6. Don I. Phillips, who has joined the staff of the AAAS Office of Public Sector Programs, performed most of the detailed budget analyses, wrote the greater part of Chapter 3, and provided valuable assistance on the entire report, together with Catherine Lighthizer, Roger Long, Kathryn Wolff and Anne Holdsworth, and other members of the AAAS staff. To all of these, and to Mr. William D. Carey, Executive Officer of the AAAS, my thanks for their assistance and patience. The interest and support of the Alfred P. Sloan Foundation is again gratefully acknowledged. The responsibility for errors of commission or omission is mine.

WILLIS H. SHAPLEY

Washington, D.C.
April 1977

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Overview of the Report

This is the second in a projected series of annual reports on research and development in the federal budget prepared for the AAAS and its Committee on Science and Public Policy to contribute to the understanding and discussion of R&D budgets and issues. It is addressed both to the scientific and technical community and to the wider community, in and out of government, which is concerned with R&D programs and policy.

One purpose is information and analysis. What is in the budget for R&D? How does the budget process work? What are the issues? The prospects for the future? What concerns should the scientific and technical community express to the decision-makers in government?

A second purpose is to use R&D budgets as a framework for considering broader aspects of R&D. Patterns and trends in R&D budgets, carefully interpreted, can identify and illuminate basic questions of R&D policy. Problems in the R&D budget process may be symptoms of more fundamental problems of decision-making, evaluation, and priority setting in R&D. The budget is the main testing ground for proposals to reform or redirect the national R&D enterprise.

The first report in the series, which we shall refer to as AAAS–77[1], laid a foundation for succeeding volumes by providing a general explanation of the budget process and discussing how R&D is handled in the budget, the general composition of the R&D budget, the problems of interpreting budget statistics, and the principal R&D budget issues of perennial concern. It also gave a summary analysis of the President's budget for fiscal year 1977 and the amounts for research and development in it. Finally, it discussed the possibilities and limitations of a continuing AAAS R&D budget project centered around an annual report on R&D in the federal budget and an annual AAAS June colloquium for discussion of budget issues.

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[1] Citations to this and other publications referred to in the text will be found in the list of references on page 141.

AAAS–77 was intended as a trial run; the report and the proposed annual AAAS R&D budget review were discussed by leading figures in the scientific and technical community and officials of the Executive Branch and the Congress at a colloquium in Washington on June 15 and 16, 1976. The response at the colloquium and to AAAS–77 when subsequently published led the AAAS and the Committee on Science and Public Policy to proceed with a second annual report and plans for a second colloquium to discuss federal R&D budget issues in June 1977.

The aims of this year's report, are twofold: first, to provide a timely analysis of federal R&D budgets for FY 1978 and to identify significant current and future issues for discussion; and second, to present some special topics that have also been selected for discussion at the colloquium.

Part I updates, in somewhat more depth, the budget analyses of AAAS–77. Chapter 1 reviews the genesis of the FY 1978 budget. It describes what happened to the FY 1977 budget, the circumstances surrounding the preparation of the FY 1978 budget, and how President Carter's amended budget evolved in the transition process. Chapter 2 looks briefly at the overall budgets for FY 1978 as proposed by President Ford and subsequently amended by President Carter. Chapter 3 describes the policies underlying the R&D budgets for FY 1978, reviews the R&D totals and the trends they reflect, and analyzes the R&D budgets of eight agencies in the degree of detail that has been possible. Finally, in Chapter 4 we discuss the future outlook for R&D budgets, make some "imaginary" projections, and end with a list of budget issues that deserve study and discussion.

Part II addresses the two special topics selected by the Committee on Science and Public Policy for consideration this year: the basis for R&D budget decisions and the role of Congress. Chapter 5 builds on the discussion in AAAS–77 to lay out for consideration a "strawman" concept of how R&D budget decisions should be made. The purpose is to provide a specific proposal to focus discussion and help the scientific and technical community and government decision-makers arrive at a consensus on the approaches and criteria that should be used in decisions on federal budgets for R&D. Chapter 6 presents a picture of the workings of Congress as they relate to R&D budgeting, written by Mr. Herbert Roback, to which has been added a list of selected questions and issues for discussion and further study.

As in AAAS–77, the role of the AAAS and this report in the analysis of R&D in the federal budget is not one of special pleading for R&D – either for particular programs or for R&D in general. Rather, it is to promote a wider understanding in the scientific and technical community of the federal budgets for R&D, the budget process, and of R&D budget issues of general interest, and at the same time, to promote a better appreciation on the part of government decision-makers – executive and congressional – of the budgetary problems of research and development.

I

R&D Budgets, Trends, and Issues

Part I

Introduction

As we approach the study of the FY 1978 budget and what it means for R&D, it will be well to have in mind what the budget is and the principal features of the budget process. To capsulize the detailed discussion in AAAS–77, we recall that the budget is basically the government's plan of operation which relates the work to be done to the dollars needed. Each year's budget arises out of long-range plans and prior budgets, is developed by the agencies of the Executive Branch, reviewed and scrubbed by the Office of Management and Budget (OMB), approved or modified by the President, and submitted by him to Congress in January, a little more than 8 months before the start of the fiscal year (new style) on October 1. Congress sets overall boundaries on the budget and reviews the principal expenditures in detail—often twice, once for "authorization" and once for the "appropriations" that actually make the money ("budget authority") available to be spent. The agencies take over again at this point and under the watchful eye of OMB proceed to make allocations, obligations and expenditures ("outlays") to carry out the approved programs. Each cycle is a sporty course of as many as 123 separate steps, with several overlapping cycles in motion at all times. The entire bewildering process is the essential vehicle by which virtually all federal programs and policies are proposed, debated, and decided in the context of our constitutional and political system.*

We should also recall that research and development is not a separate entity in the federal budget. Research and development activities are carried in the budgets of some ninety separate federal agencies and major subdivisions; in each case the R&D budgets wend their way through the process along with the rest of the agency's budget, with some coordination of related R&D budgets by the agencies themselves, OMB, and the Office of Science and Technology Policy (OSTP). "R&D budgets" are mostly statistical abstractions from broader budgets. The

* See AAAS–77, Chapter 1 and Appendix.

principal sources of comprehensive statistics on federal R&D budgets are the "Special Analysis P"[1] published by OMB with the annual budget and a series of more detailed analyses by the National Science Foundation which appear many months later.

Finally, we must not forget the many necessary caveats on the use of R&D budget statistics. The analysis of R&D budget statistics, if done in moderation and not pushed too far, can be a useful approach in studying federal R&D programs to identify trends and issues. But the interpretation of budget statistics is shot through with pitfalls and easy fallacies. Budget statistics measure money that is being spent, but not the results, quality, value, or priority of what it is spent for. Budget figures may be indicators of relative "levels of effort," provided that factors like overhead, equipment needs, and nonrecurring financial adjustments can be assumed to be equal, which is, however, generally not the case. Increases and decreases in R&D budgets may signify important program changes, but perturbations due to inflation, accounting changes, and other estimating distortions can easily lead to erroneous conclusions. Serious students of federal R&D must go behind the budget statistics and examine each R&D program and its budget in the real world context in which it exists.[2] We will find many examples of statistical anomalies in the analysis of R&D in the FY 1978 budget.

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[1] "Special Analysis P," in *Special Analyses: Budget of the United States Government: Fiscal Year 1978* (Washington, D.C.: Government Printing Office, 1977).

[2] See AAAS-77, pp. 21–25.

Chapter 1

The Genesis of the FY 1978 Budget

The best place to start to gain some insight into the context in which the FY 1978 budget was developed is to hop back on the moving merry-go-round of the budget cycle at the point we left it in AAAS–77 and see what happened to President Ford's FY 1977 budget as it worked its way through Congress. Then we can step over to the already moving FY 1978 cycle, and see how President Ford developed his last budget and how his successor went about amending it.

A. What Happened to the FY 1977 Budget?

President Ford's budget for FY 1977 was reshaped in important aspects by Congress. His draconian proposals for restraint in increases in social programs were mostly set aside. The Democratic majority in Congress had no compunction in raising the ceiling on total outlays from $394 billion to $413 billion. The President's proposal for a massive $15 billion increase in military appropriations was cut by $3 billion, but the Defense Department still got the biggest boost in peacetime history and approval of most of its major program proposals. Generally, Congress took a somewhat relaxed view of agency budgets; increases over the President's proposals were approved in many cases.

For R&D, it was something of a mixed bag. Exact statistical analysis is not possible because Congress does not act on R&D as such in most agencies, but, as shown in Table 1, it appears that the net effect on the R&D total was a plus of about $175 million.

Defense sustained the biggest R&D cut, $420 million from the January budget, plus another $200 million representing Congressional rejection of the entire R&D portion of a billion dollar Navy budget amendment for a massive new program to rebuild the fleet which the President sent to Congress in May. However, the Department apparently won Congressional approval of its basic proposition that the

United States must embark on a major expansion of military R&D efforts to keep pace with Soviet advances. It also gained acceptance, for a second year, of the policy strongly urged by the Director of Defence Research and Engineering, that each year there should be real increases (in addition to increases to cover inflation) of 10 percent and 5 percent in the DOD budget categories for "Research" and "Exploratory Development," respectively.

The Energy Research and Development Agency and the National Institutes of Health won the largest Congressional increases. ERDA got an increase of about $250 million for R&D over a Presidential budget that already called for an increase of some $650 million (18 percent) over FY 1976. R&D in the fields solar energy, energy conservation, and fusion power were singled out for the largest increases of 130 percent, 41 percent, and 36 percent, respectively. The forced feeding of ERDA with large increases each year may raise some questions as to whether ERDA can utilize the funds at the rate they are being provided.

NIH, as expected, received a whopping increase over the budget of about $350 million, some 16 percent. The FY 1977 budget estimates for NIH and other HEW R&D were artificially low because they were based on the assumption that the President's veto of the Congressionally increased HEW FY 1976 budgets would be sustained. The Congressional override of the veto established a higher base for FY 1977 and, as expected, set the stage for another round of annual Congressionally mandated increases for NIH and other R&D in HEW. This year the President did not attempt a veto.

The National Science Foundation, proudly carrying the banner of the President's much touted 20 percent increase for basic research, received a setback in the form of a cut of about $30 million out of the total proposed increase of about $85 million; in absorbing this cut NSF has apparently been able to salvage a basic research increase of about 14 percent. Another apparent loser in the FY 1977 budget battle was the Research and Technology program of HUD, where a 22 percent cut of $16 million was assessed because carry-over funds appeared to be available. The other R&D agencies appear to have received substantially the amounts recommended in the President's budget.

The actions of Congress on R&D in the FY 1977 budget do not seem to reflect anything that could be described as a general Congressional policy or attitude on R&D. Rather, they appear to be the result of the judgments and attitudes of the individual committees and subcommittees charged with reviewing each program.

The Congress earned good marks for making its own new budget process work successfully in its first year of fullblown operation. With a few creaks and groans, both houses submitted to the self-discipline of the new process. Committee hearings were conducted on an expedited schedule that enabled most of them to meet acceptably the tight deadline of March 15 for recommendations to the Budget Committee for the first concurrent resolution setting overall limits on the budget. The first

concurrent resolution was duly passed in May and the binding second concurrent resolution in September. All major appropriation bills were passed by October 1, the start of the new fiscal year – the first time in memory that this has ever happened – although every day of the extra 3

Table 1. Congressional Changes in the FY 1977 Budget: Principal Identifiable R&D Items (Budget Authority in millions)

	FY 1977 Budget	Approved by Congress	Changes	
			Amount	Percent
Department of Defense (DOD):				
Research, Development, Test and Evaluation (RDT&E) Accounts	$10,854	$10,434	−$420	−3.9%
Budget Amendment	(200)	(−)	(−200)	(−100.0%)
Energy Research and Development Administration (ERDA):				
Principal R&D Items	2,833	3,085	+252	+8.9%
National Aeronautics and Space Administration (NASA): Total	3,697	3,693	+4	−0.1%
National Science Foundation (NSF):				
Research Related	741	710	−31	−4.2%
National Institutes of Health (NIH): Total	2,165	2,531	+366	+16.9%
Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA):				
Research	127	151	+24	+18.9%
Veterans Administration:				
Medicine and Prosthetic Research	97	101	+4	+4.3%
Housing and Urban Development (HUD):				
Research and Technology	71	55	−16	−22.5%
Environmental Protection Agency (EPA):				
R&D, combined	256	260	+4	+1.4%
Nuclear Regulatory Commission (NRC):				
Research	122	117	−5	−4.1%
TOTAL, above items	$20,963	$21,137	+$174	+0.8%

Source: Derived from Congressional appropriations reports, 94th Cong., 2d sess.

months gained by moving the start of the fiscal year from July 1 to October 1 was needed. Of course, there were a few casualties. The ERDA authorization bill died at adjournment because the House and Senate could not resolve a dispute. ERDA found itself in the unusual position of having its appropriations approved but not the underlying authorizations. The National Institute of Education was not so fortunate. When its authorization bill bogged down, the appropriations committees refused to include an appropriation in the pending appropriations bill; the result was that the NIE was forced to operate under a "continuing resolution," the traditional way of tiding an agency over into a new fiscal year until Congress can catch up with the calendar.

B. The Preparation of the FY 1978 Budget

While the FY 1977 budget was working its way through Congress, the preparation of the FY 1978 budget proceeded quietly against the backdrop of President Ford's desperate campaign against Ronald Reagan for the Republican nomination. His position on national defense continued to harden to meet the conservative challenge. Budget ceilings were handled in ways that would avoid creating new opposition within Republican ranks. Few new guidelines were needed; the advance planning for FY 1978 contained in the FY 1977 budget was generally sufficient. Mostly the process was left to the professionals in the departments and to OMB; the administration's political focus was first on the convention and then on the campaign.

OMB review of agency estimates began on schedule early in September and was substantially complete by election time. As a new procedure, detailed estimates were required from the agencies for FY 1979 as well as FY 1978. This was partly in furtherance of the trend to multi-year budgeting – strongly supported by the President – and partly to provide detailed figures to support the President's publicly stated goal that his FY 1978 budget would be based on policies and decisions that would balance the budget in FY 1979. In the internal OMB reviews of the FY 1978 budget, R&D apparently received more attention than usual. It is said that OMB Director Lynn interested himself personally, especially in the various different types and functions of R&D, and kept the staff hopping to provide crosscuts of R&D estimates on a variety of different bases.

The disappointment and fatigue of the President and his administration from the loss of a close election after a strenuous campaign caused some delay, but by late November the President was personally reviewing OMB's budget recommendations and personally hearing appeals from aggrieved agency heads. The worsening economic situation led to abandonment of the goal of a balanced budget in FY 1979, but except for this concession President Ford went right down the line in

again configuring a stern, conservative budget for FY 1978 as he had done for FY 1977.

With regard to R&D budgets, the closed doors of executive secrecy surrounding Presidential budget decisions swung ajar once or twice to let out some hopeful signs. One visitor quoted the President as saying that he was doing good things for science in his final budget; "I had to increase some of the recommendations they brought me," he is said to have said.

Even more remarkable was the meeting the President held on December 16 at the White House, apparently arranged by the President's science adviser, Dr. H. Guyford Stever, who had finally been confirmed late in the summer as the Director of the reestablished and renamed Office of Science and Technology Policy. In attendance were the heads of most of the principal R&D agencies in the government; a couple of cabinet officers; top OMB officials; and about a dozen leading nongovernmental figures concerned with science and technology, including the presidents of the National Academies of Sciences and Engineering and the National Institute of Medicine, the heads of some professional, educational, and public interest organizations, some university and industry scientists, and a few others—a total of about thirty people. At the meeting, the President, Dr. Stever, and others explained the principal features of the R&D budget decisions the President had made, and there was a friendly and enthusiastic discussion of some of the specific projects. Immediately afterward, Dr. Stever held a press conference at which he reported generally on the meeting and revealed much of the content and thrust of the President's budget decisions on R&D. As is customary, he adhered to the standard ground rule that actual budget figures are not releasable until the budget is sent to Congress.

From this press conference, the world could learn that the FY 1978 budget would include a substantial real increase for basic research; a new competitive grant program for basic research in agriculture; and new starts in the space program, including the space telescope and Jupiter orbiter-probe projects and an advance technology earth resources survey satellite. Dr. Stever reported the President's and Vice President's interest in the problem of earthquakes and foretold an accelerated R&D program in this area. He also discussed a new initiative in ERDA for studying nuclear fuel cycles that do not require separation of plutonium from uranium, which might help minimize the dangers of nuclear proliferation. He mentioned the President's continuing interest in strengthening defense R&D and in a strong health science program, but said these areas had not been discussed at the meeting because of time constraints. He concluded by pointing with understandable pride to "the progress that has been made in the communications between the scientific world and the White House of which this meeting is one evidence."

C. The Transition Begins

There is a long tradition in the United States of orderly and generally friendly transitions when a new President takes office, even when he is of the other political party. The Carter transition, however, has had some unusual features. A large and enthusiastic transition team was set up several months before the election. Their task and the actual transition were complicated, however, by the lack of inside experience in the workings of the federal government on the part of the President-elect and most of his entourage, and the somewhat tenuous relationships that existed both between the transition teams and the rest of the Carter group and between the entire Carter group and the Democratic establishment, especially in Congress. As a result the transition moved much more slowly than in previous turnovers; the new President obviously decided to take first things first and to ease more gradually into the myriad other responsibilities of his new office.

This pattern was especially evident in his approach to budget matters. One of his first announced appointments was that of Mr. Bert Lance to be Director of OMB. But the focus of his preinaugural budget discussions with his new team was on a fiscal stimulation package of increased expenditures and tax reductions to deal with the worsening economic situation. This preoccupation, combined with a somewhat surprising refusal of the Ford administration to allow direct working contacts by Carter transition people with the OMB professional staff until after President Ford's budget decisions had been made, meant it was not until President Carter had been inaugurated that the new decision-makers began to look at the FY 1978 budget in concrete terms and consider what changes they might make in it. Even then, the going was very hard because so many policy-level positions were to remain unfilled for many weeks.

The new administration was under strong time pressure to make quick decisions on budget changes or to defer them to the FY 1979 budget cycle. In previous transitions the new President has typically submitted his amendments to his predecessor's budget about the end of March, sometimes even later. The new Congressional Budget Act, however, sets a rigid timetable for Congressional consideration of the budget which gives no special period of grace to an incoming President. President Carter decided to submit promptly only a limited number of proposed changes in the budget and to defer a complete review of the budget to the FY 1979 cycle. The amended FY 1978 budget sent to Congress on February 22, 1977, accordingly reflected the administration's economic stimulation package; some significant policy changes in defense, energy, and a few other areas; and a number of other adjustments based on suggestions by the transition staff and advice from the OMB staff.

Chapter 2

The FY 1978 Budget

This chapter sets the stage for our discussion of R&D in the FY 1978 budget. Federal R&D is woven into the rest of the budget and subject to the President's overall fiscal policies and political outlook. A brief sketch of the principal features of the overall FY 1978 budget submitted to Congress by President Ford in January and the amendments submitted by President Carter a month later will help clarify the context in which the budget decisions on R&D were made.

A. The Ford Budget

The outgoing President's budget was almost completely eclipsed by preparations for the inaugural 3 days later and by public anticipation of the coming of the new administration. It was generally ignored by the media, barely making page one in major newspapers; commentators tended to dismiss it as a dead letter, to be superseded shortly by a new Carter budget. As it turned out, President Carter actually made only a few, albeit significant, amendments—most of the budget remained unchanged. For better or worse, President Ford's budget, as Congress modifies it, will be the basic plan for most of the operations of the federal government in FY 1978.

As required by law and custom, the budget President Ford presented on January 17, 1977, included all the details and supporting documentation as if he were continuing in office. The budget message was brief and pithy, a valedictory restatement of the stern fiscal outlook of his administration. The budget itself was the first true 2-year budget in history; it included complete estimates for FY 1979, down to the agency and subfunction level of detail, in addition to the customary detailed estimates for FY 1978 and overall projections for the next 5 years.

The Budget Message set a new record for conciseness; its four and a

half pages addressing only a handful of policy points were a far cry from the dozens of pages cataloging the entire federal program that once were standard fare. There was a severe lecture on fiscal responsibility, some finger-pointing at Congress for its failure to support the President's FY 1977 budget, and some modest pointing with pride at the achievements of the outgoing administration. The President said some hard things to Congress about the workings of Congress itself and the need for reforming its attitudes and organization; a President leaving office in 3 days could and did break the taboos that normally protect Congress from this kind of "the Emperor has no clothes" criticism by the Executive Branch.

The policy points which President Ford chose to stress in his short Budget Message included the overriding need to reduce the rate of increase in federal spending and the needs for tax reductions and consolidation of domestic assistance programs. Only two budget increases were singled out for mention: national defense and, surprisingly, "basic research and development." For R&D, or at least for basic R&D—it is not clear if applied research was intentionally or accidentally excluded—the President said he was again proposing real growth. He was convinced that "we must maintain our world leadership in science and technology in order to increase our national productivity and attain the better life we want for our people and the rest of the world." By this special endorsement, he confirmed earlier indications that R&D would indeed receive special treatment in his FY 1978 budget.

Table 2 shows the totals and illustrates the main thrusts of the Ford budget. It shows a steady increase in defense spending at a rate substantially exceeding the assumed rates of inflation. Benefit payments to individuals also show a steady climb, but the figures reflect drastic cutbacks of $20 to $40 billion in what would be spent each year for these programs under present laws and policies. This is the focus of President Ford's efforts to reverse past trends and slow the rate of growth in government spending. It is also a major area of difference with the Congress in which the Democratic majority has consistently rejected Nixon and Ford proposals for similar cutbacks as undesirable, or unrealistic, or both. Grants-in-aid to states and local governments is another battleground where Congress generally has favored large increases for federally financed job-programs. In both of these areas, the Ford proposals to cut back spending are almost certain to be ignored.

The "all other" entry in Table 2 illustrates the basic problem that characterizes President Ford's FY 1978 budget. It shows clearly how he believes the rate of increase of spending for government operations should be slowed down. But is it realistic to expect FY 1979 expenditures to be held to an overall increase of 4 percent in the face of inflation estimated at about 6 percent? Can an increase of only 9 percent from FY 1979 to 1982 meet both needs and inflation? The figures are optimistic, to say the least. They are not likely to be accepted by the Carter

administration as the yardstick for measuring its fiscal performance over the next 4 years.

B. The Carter Amendments

President Carter's amendments to the FY 1978 budget, prepared under heavy time pressure, were submitted to Congress on February 22, 1977, in a document entitled *Fiscal Year 1978 Budget Revisions* which addresses succinctly the selective budget changes proposed and includes revised versions of the most pertinent summary tables. There are no estimates for FY 1979 or future years. President Carter makes it clear that "the 1978 budget is essentially still President Ford's budget, with only such limited revisions as my administration has had time to make."

President Carter's short and somewhat choppy message recites the major policy changes he has made in the FY 1978 budget. These include withdrawal of Ford budget proposals in the health and welfare area; a reduction in the planned increase in defense spending; and new priorities for water resources development and energy, with greater emphasis on conservation, development of non-nuclear power sources, and expanding the nation's petroleum storage program. The budget amendments also include, with slight revisions, the economic stimulation package previously sent to Congress. There was no mention of R&D as such.

Table 2. Summary of FY 1978 Budget (as submitted by President Ford, January 17, 1977; in billions)

	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget	FY 1979 Planned	FY 1982 Projected
Outlays					
National Defense	$ 90.0	$100.1	$112.3	$123.8	$159.0
Benefit Payments to Individuals	167.3	183.7	193.6	206.7	257.0
Other Grants to State & Local Governments	39.5	46.9	46.1	44.1	43.0
Net Interest	26.8	29.8	31.1	32.7	34.8
All Other Federal Operations	42.9	50.7	56.9	59.2	64.9
Total Outlays	$366.5	$411.2	$440.0	$466.0	$558.7
Receipts (total)	$300.0	$354.0	$393.0	$454.0	$587.3
Deficit (−) or margin (+)	−$ 66.5	−$ 57.2	−$ 47.0	−$ 11.6	+$ 28.6
Budget Authority (total)	$415.5	$435.9	$480.4	$518.6	$623.9

Source: FY 1978 Budget and Congressional Budget Office Overview of the 1978 Budget.

Table 3. Summary of Amended FY 1978 Budget (as amended by President Carter, February 22, 1977; in billions)

	FY 1977			FY 1978		
	January Budget	Amended Budget	Change	January Budget	Amended Budget	Change
Outlays						
National Defense	$100.1	$100.1	—	$112.3	$111.9	−$ .4
Benefit Payments to Individuals	183.7	187.6*	+$ 3.9*	193.6	198.7*	+5.1*
Other Grants to State & Local Governments	46.9	48.8	+ 1.9	46.1	55.9	+9.8
Net Interest	29.8	30.1	+.3	31.1	33.1	+2.0
All Other Federal Operations	50.7	50.8*	+.1*	56.9	59.8*	+2.9*
TOTAL Outlays	$411.2	$417.4	+$ 6.2	$440.0	$459.4*	+$ 19.4
Receipts (total)	$354.0	$349.4	−$ 4.7	$393.0	$401.6	−$ 8.6
Deficit (−)	−$ 57.2	−$ 68.0	+$10.8	−$ 47.0	$ 57.7	+$ 10.8
Budget Authority	$435.9	$464.0	+$28.1	$480.4	$507.3	+$ 26.8

Source: Fiscal Year 1978 Budget Revisions, February 1977.
* Category totals estimated from detailed data.

The budget changes recommended by President Carter for FY 1977 and FY 1978 are summarized in Table 3. The outlay reductions in national defense reflect a $2.7 billion net reduction in budget authority, chiefly slowing down or delaying the initiation of various procurement, development and other programs. No major change in military posture is proposed, but many of the reductions, especially in the strategic weapons field, are intended to preserve the administration's flexibility as it makes a thorough review of national strategy and defense programs. The increase in payments to individuals and grants to state and local governments reflects the antirecession stimulation package and restores some of the unrealistic or unpopular cuts in the Ford budget. The net change in other federal operations includes a net increase of $832 million in outlays for energy programs ($1.3 billion in budget authority); a reduction of $254 million in water resource projects; an increase of about $400 million for highway and railway programs; and many other increases and adjustments. The large increases in total budget authority in FY 1977 and FY 1978 are somewhat misleading because they include substantial amounts for proposed long-term housing assistance programs for which the spending will be spread over a 15- to 40-year period.

Chapter 3

R&D in the FY 1978 Budget

In this chapter we will first look at the overall features of the R&D proposals in President Ford's budget, the policies on which they were based, and the modifications made by President Carter. Then we will examine the R&D budget statistics for FY 1978 in some detail, analyzing the trends in categories of interest where data are available, and close by discussing some of the significant features of the R&D budgets in selected R&D agencies.

A. Ford Emphasizes, Carter Adjusts

1. The Ford Proposals for R&D

As presaged by the advance teaser of Dr. Stever's press conference in December, R&D did indeed receive special emphasis in President Ford's FY 1978 budget. As we have seen, R&D, specifically "basic research and development," was one of only two areas in which the President personally endorsed increases in his brief Budget Message; in the other area he mentioned—national defense—the emphasis on systems which will be needed 10 years from now also implied additional emphasis on R&D. As we will see in Table 4a, the total of all the R&D funds recommended by President Ford increased over FY 1977 by 10.7 percent in budget authority to an all-time high of $28.0 billion. This represents a real increase of about 4.7 percent after allowing for inflation at the assumed rate of about 6 percent. Although some agencies and programs did better than others, all in all, it was a good year for R&D.

In the detailed materials supporting the FY 1978 budget and in the summary statement on R&D contained in "Special Analysis P," the Ford administration stressed the following features of its R&D budget recommendations:

(1) Defense R&D: A commitment to the modernization of defense

equipment and the provision of new options for future weapons systems.

(2) Basic Research: Further real growth in the overall level supported by the federal government.

(3) Agriculture: Begin a new program of competitive grants for fundamental research.

(4) Earthquakes: Double the level of funding for an interagency research program.

(5) Health: Increase funding for competitive research grants.

(6) Remote sensing: Another experimental satellite to continue tests of techniques of crop forecasting and other resource surveys from space.

(7) Air Traffic Control: R&D to upgrade system.

(8) Energy: Continued major increases in R&D; special emphasis on fossil fuels, other non-nuclear technologies, conservation, and nuclear safety; continuation of breeder reactor and fusion programs.

(9) Space: Initiate space shuttle procurement, space telescope development, and an orbiter and probe mission to Jupiter.

2. *R&D Policy in the FY 1978 Budget*

The official papers accompanying President Ford's FY 1978 budget give a much fuller exposition than ever before of the policies and rationales underlying the R&D estimates in the budget. *Issues '78,* the collection of papers prepared by OMB to help explain, sell, and defend the President's budget, included issue papers on federal R&D generally; federal support of basic research; the National Science Foundation; NASA; earthquake hazard reduction; agricultural research; and energy research, development and demonstration. These papers, also made available by OMB in a convenient package entitled *Research and Development Issues,* merit careful reading by all concerned with federal policy on R&D. In addition to supporting the decisions of the Ford administration, they obviously reflect some carefully thought out views and general attitudes of the permanent OMB staff, a fact which gives them more than one-time significance. OMB's institutional views and approach to R&D, as on other matters, can be counted on as an important force in shaping the new administration's policies in future years.

The principal points on general R&D policy can be summarized under five heads, largely in the words of the *Issues '78* papers themselves.

a. Rationale for Federal Government Support of R&D

The federal government invests in R&D largely to improve its capability to supply services to the people, and to carry out government responsibilities such as defense. R&D should not be viewed as an "end-in-itself," but as a means whereby agency and national goals can be

achieved more effectively or more efficiently. The federal government seeks to encourage—through its R&D programs, as well as through other incentives—continued and expanded private investment in R&D so that over-all national goals may be better met through advances in technology.

b. Federal R&D Strategy

The federal government focuses its R&D investment in three broad areas to meet (i) *direct federal needs*, where the government accepts full responsibility, such as in space exploration, national defense, air traffic control, and in setting regulatory standards; (ii) *general economic and human welfare needs*, where the federal government assumes major responsibility because there are insufficient incentives for the private sector to invest enough to meet national needs, such as in basic research, medicine, environmental protection, earthquake prediction, and agriculture; and (iii) *specific national needs*, where the government shares responsibility and uses federal funds to accelerate and augment—through cost-sharing—the efforts of the private sector because of the need to provide the nation with future technological options, such as new energy technologies or advanced components for future civilian and military aircraft.

c. Need for Budgetary Constraints

Constraints must be exercised and priorities set for R&D not only because of overall budget limitations, but also (i) to avoid overtaking private sector responsibilities for producing, marketing, and applying technical advances for use in industrial manufacturing where individual companies would be the beneficiary and hence would have a strong financial incentive for their use, and (ii) to avoid investing in technology where user demands and future economic viability are highly uncertain.

d. Basic Research

There is an emerging consensus among economists, the business community, the Congress, and the administration that the federal government has a key responsibility in assuring an adequate level of national support for basic research. The federal government has accepted the primary responsibility for funding basic research across a broad range of scientific disciplines, acknowledging that the general advancement of scientific knowledge is essential to the continued growth of the national economy and to the solution of important national concerns in areas such as health, environment, energy and natural resources. The normal economic incentives of the marketplace cannot be relied upon to assure that adequate investments in basic research will result from the private decisions of commercial enterprises. Mission agencies of the federal government also need basic research to acquire fuller knowledge or understanding important over the long-term to achieving their goals and objectives.

e. Adequacy of Total National Investment in R&D

Innovation and productivity in the civilian industrial sector are essential. The federal government's responsibility is to identify problems that might be adversely affecting innovation and productivity, and seek appropriate programs and policy solutions. However, uncertainties and questions continue to exist concerning whether there is a real problem with respect to the overall level of U.S. investment in R&D and the extent of federal actions that might be taken, particularly in areas where the private sector has the major responsibilities.

There is much food for thought here. Taken as a whole, the Ford–OMB view of R&D policy is a far cry from the negativism the R&D community tends to associate with OMB. It is certainly not antiscience; its support for basic research appears unqualified. It reveals a deep and continuing policy commitment to R&D. There may be some disagreement with its view of the policy boundaries between federal and private R&D in areas of joint responsibility (for example, energy) and on its attitude toward the need for more R&D to increase economic productivity. But by and large it does not appear that the scientific, technical, and public policy communities should have any major quarrels with it. R&D ended the Ford administration in a strong policy position.

3. The Carter Changes in R&D

President Carter's budget amendments of February 22, 1977, did not signal any general change in federal R&D budget policy. The net effect on the totals for R&D in the budget was a reduction of about $320 million or 1.1 percent in budget authority; this reduction reflects primarily the impact on R&D of policy changes the President proposed in two specific areas, defense and energy, with the substantial net reductions in those areas offset a bit by minor upward adjustments in a few other R&D programs (for example, NASA, NIH, and education R&D in HEW).

In defense R&D, the downward amendment of about $260 million results mainly from decisions to slow down or postpone certain weapons systems programs. The two biggest reductions cut back the M–X ICMB system and the army's advanced attack helicopter, two programs that had been given special emphasis in President Ford's FY 1978 budget; there are also smaller adjustments, up and down, in about a dozen other R&D items. While some have seen in the Carter defense amendments some relaxation of the Ford administration's drive to strengthen our national defense capabilities, the Carter administration has stressed rather its need to maintain its flexibility while it makes a thorough review of U.S. defense policies and programs prior to submitting the FY 1979 budget.

In energy R&D, the Carter amendments to the FY 1978 budget make some significant reorientations. There are increases of $160 mil-

lion and $42 million for energy conservation R&D and fossil fuel technology demonstrations, respectively. These increases are more than offset, however, by a major cutback in the Liquid Metal Fast Breeder Reactor (LMFBR) program, which is cut to below the FY 1977 level, and smaller cutbacks in fusion and other nuclear power R&D. The general approach of the Carter administration's energy policies is clearly stated: increased emphasis on energy conservation and petroleum storage, and decreased emphasis on long-term energy R&D. By the time these words are published, the Carter administration's comprehensive energy program, promised for April 1977, will presumably have been made public.

The other Carter budget amendments affecting R&D appear to be minor adjustments to restore a few of the specific reductions made during the preparation of the Ford budget. NASA recovered an additional $10 million for studies of a follow-up to the Viking Mars missions and $5 million to allow inclusion of a back-up to the new earth resources survey satellites included in the Ford budget. NIH got $5 million more for reproductive physiology and studies of prenatal development in the National Institute of Child Health and Human Development, and the Assistant Secretary for Education received an additional $3 million for museum-related activities.

President Carter's statement that the FY 1978 budget is still essentially President Ford's budget applies with full force to its R&D components. In the one month between Inauguration Day and the submission of the budget amendments, the new administration clearly did not focus on the merits of all the R&D programs in the Ford budget. In fact, most of the key R&D management positions in the administration had not yet been filled – there was no new Director of Defense Research and Engineering, no new Director of NSF, no new Administators of NASA, or NOAA, and no new Director of OSTP, to name a few of the missing players on the new team. Whether the Carter administration will make major changes in the R&D budget policies and budget levels of the Ford administration will probably not be known until these and other new appointees are heard from and the new leadership in OMB and the President come to grips with the specific details of the FY 1979 budget.

B. R&D Totals and Trends

For the FY 1978 budget, overall statistics on research and development are available on three bases: (1) *budget authority*, generally corresponding to the funds appropriated each year, (2) *obligations*, indicating the amounts of contracts, grants, or other commitments entered into each year, and (3) *outlays*, representing the amounts expended – for example, actually paid out – during each year. As discussed in AAAS-77, each of these measures has its own advantages as an indicator of what is going on in R&D, and each may be subject to estimating aberrations which may distort the actual trends in funding.[1] In the FY 1978 budget,

Table 4. Total R&D Budgets for FY 1978: Original (Ford) and Revised (Carter) FY 1978 Budgets (in billions)

4a.	Budget Authority for R&D in FY 1978 Budget				
	FY 1972[1] Actual	FY 1976 Actual	TQ Actual	FY 1977 Est.	FY 1978 Budget
Conduct of R&D:					
Original budget	$16.5	$21.2	$5.4	$23.7	$26.4
Revised budget	16.5	21.2	5.4	23.7	26.3[2]
Same, 1972 dollars	16.5	16.1	4.1	16.8	17.6
R&D Facilities:					
Original budget	$ .6	$ .8	$ .2	$ 1.6	$ 1.6
Revised budget	.6	.8	.2	1.6	1.4[2]
Same, 1972 dollars	.6	.6	.1	1.1	.9
Total R&D:					
Original budget	$17.1	$22.0	$5.6	$25.3	$28.0
Revised budget	17.1	22.0	5.6	25.3	27.7
Same, 1972 dollars	17.1	16.7	4.2	17.9	18.5

Source: "OMB Data for Special Analysis P," Ford Budget and Revised.

[1] Budget Authority figures are not available for FY 1972. Data shown are authors' estimates based on obligation data.

[2] The revised data for "Special Analysis P" do not include budget authority. Budget authority estimates are based on obligation data.

the estimates of budget authority and outlays appear to be the best indicators of overall trends, and we will look at R&D chiefly in these terms. We shall see that the figures for obligations contain several major anomalies which make the indicated trends misleading; this is unfortunate because most of the detailed analyses of prior trends in the NSF and other reports are available only in terms of obligations.

Table 4 shows the totals for R&D in the original budget (President Ford) and the revised budget (President Carter). Tables 4a and 4b show that the revised FY 1978 budget calls for increases of about 9.5 percent (budget authority) and 11.9 percent (outlays) over FY 1977. In constant dollars, these increases drop to 3.4 percent and 6.0 percent, respectively, and the increases over FY 1972 are only 8.2 and 5.3 percent. We see that in FY 1978 all of the real increase in budget authority is in conduct of R&D; budget authority for facilities decreases in real terms. But, as would be expected, outlays for facilities increase by 14.3 percent in constant dollars in FY 1978 following the large increases in budget

[1] The principal sources of FY 1978 budget statistics on R&D are "Special Analysis P," other special analyses in the same volume, *Issues '78*, and the Congressional budget estimates of the various agencies. In addition, OMB kindly furnished the authors with additional data used in compiling the original and revised "Special Analysis P" cited as "OMB Data for Special Analysis P," Ford budget and revised, respectively. The data for the Ford budget include budget authority figures in addition to the obligations and outlays presented in "Special Analysis P."

authority and obligations that occurred in FY 1977. (Agency detail for these totals in conduct of R&D and R&D facilities is provided in Tables 13, 14 and 15.)

Now let us look at the "crosscuts" that provide some insight into the trends within the R&D totals for which data for FY 1978 are available in the President's budget and supplementary documents. (Some additional

4b.	Outlays for R&D in FY 1978 Budget				
	FY 1972 Actual	FY 1976 Actual	TQ Actual	FY 1977 Est.	FY 1978 Budget
Conduct of R&D:					
Original budget	$16.2	$20.3	$5.4	$22.6	$25.3
Revised budget	16.2	20.3	5.4	22.6	25.2
Same, 1972 dollars	16.2	15.4	4.1	16.0	16.9
R&D Facilities:					
Original budget*	$ .6	$ .8	$ .3	$ 1.0	$ 1.3
Revised budget	.6	.8	.3	1.0	1.2
Same, 1972 dollars	.6	.6	.2	.7	.8
Total R&D:					
Original budget*	$16.8	$21.1	$5.7	$23.6	$26.6
Revised budget	16.8	21.1	5.7	23.6	26.4
Same, 1972 dollars	16.8	16.0	4.3	16.7	17.7

Source: "OMB Data for Special Analysis P," Ford Budget and Revised.
* These amounts differ from "Special Analysis P" because of updated figures for HEW.

4c.	Obligations for R&D in FY 1978 Budget				
	FY 1972 Actual	FY 1976 Actual	TQ Actual	FY 1977 Est.	FY 1978 Budget
Conduct of R&D:					
Original Budget	$ 16.5	$20.7	$5.5	$24.5	$26.3
Revised Budget	16.5	20.7	5.5	24.5	26.2
Same, 1972 dollars	16.5	15.7	4.1	17.4	17.5
R&D Facilities:					
Original Budget*	$ .6	$ .8	$ .3	$ 1.6	$ 1.7
Revised Budget	.6	.8	.3	1.6	1.5
Same, 1972 dollars	.6	.6	.2	1.1	1.0
Total R&D:					
Original Budget*	$ 17.1	$21.5	$5.8	$26.1	$28.0
Revised Budget	17.1	21.5	5.8	26.1	27.7
Same, 1972 dollars	17.1	16.3	4.3	18.5	18.5

Source: "OMB Data for Special Analysis P," Ford Budget and Revised.
* These figures differ from "Special Analysis P" because of updated figures for HEW.

crosscuts are presented in the Appendix, based on less current data from NSF analyses of federal support for R&D.)

1. Major Components of Federal R&D

Table 5 shows the funding totals and trends for each of the three major components into which OMB classifies federal R&D programs: "Defense," including, in addition to Department of Defense R&D, the weapons and other national security activities of ERDA; "Space," comprising NASA's space science, development, and exploration activities and an ERDA program in applications of nuclear energy to space technology, but excluding space applications and aeronautics; and "Other Civilian," which encompasses all the other federally funded R&D.

Since FY 1972, total conduct of R&D has increased by 60 percent in current dollars. "Defense" has just about kept pace, having increased by nearly 50 percent over this period. The major changes have occurred in "Space" and "Other Civilian": "Space" increased by only 18.5 percent, while "Other Civilian," which includes the popular topics of environment, energy, and other societal problem areas, gained by 102 percent. In constant dollars, only the "Civilian" component is at a level higher than in FY 1972, showing a 35 percent increase. In the current budget, both "Defense" and "Civilian" show "real" increases, 7.2 percent and 3.1 percent, respectively, while "Space" remains level.

Table 5. Major Components of Federal Funding for Conduct of R&D (Budget Authority in billions)[1]

	FY 1972[2] Actual	FY 1976 Actual	TQ Actual	FY 1977 Est.	FY 1978 Budget
Current dollars:					
Defense	$ 8.9	$10.7	$2.7	$11.7	$13.3
Space	2.7	2.9	.7	3.0	3.2
Other Civilian	4.9	7.6	2.0	9.0	9.9
TOTAL Conduct of R&D	$16.5	$21.2	$5.4	$23.7	$26.4
Constant 1972 dollars:					
Defense	$ 8.9	$ 8.1	$2.0	$ 8.3	$ 8.9
Space	2.7	2.2	.5	2.1	2.1
Other Civilian	4.9	5.8	1.5	6.4	6.6
TOTAL Conduct of R&D	$16.5	$16.1	$4.1	$16.8	$17.7

Source: Authors' estimates.

Note: Detail may not add to total due to rounding.

[1] "Special Analysis F" analyzes these components in obligations and outlays only. We have calculated budget authority figures on the basis of the definition of each component given in the text.

[2] Budget authority figures are not available for FY 1972. Data shown are authors' estimates based on obligation data.

Table 6. Conduct of R&D by Character of Work (Budget Authority in billions)

	FY 1972 Actual[1, 2]	FY 1976 Actual	TQ Actual	FY 1977 Est.	FY 1978 Budget
Current dollars:					
Basic Research	$ 2.0	$ 2.5	$ .6	$ 2.7	$ 3.0
Applied Research[3]	3.9	5.5	1.3	5.9	6.4
Total Research	5.9	8.0	1.9	8.6	9.4
Development[3]	10.7	13.2	3.5	15.1	17.0
TOTAL Conduct of R&D	$16.5	$21.2	$5.4	$23.7	$26.4
Constant 1972 dollars:					
Basic Research	$ 2.0	$ 1.9	$ .5	$ 1.9	$ 2.0
Applied Research	3.9	4.2	1.0	4.2	4.3
Total Research	5.9	6.1	1.5	6.1	6.3
Development	10.7	10.0	2.6	10.7	11.4
TOTAL Conduct of R&D	$16.5	$16.1	$4.1	$16.8	$17.7

Source: "OMB Data for Special Analysis P," and *Federal Funds*, Volume XXV, NSF.
Note: Detail may not add to total due to rounding.
[1] Budget Authority figures are not available for FY 1972. Data shown are authors' estimates based on obligation data.
[2] The FY 1972 totals are based on the revised estimates for NASA. See text.
[3] These amounts differ from "OMB Data for Special Analysis P" because of updated figures for Defense, which have been estimated from corrected obligation data.

2. *Character of Work*

Table 6 presents the R&D budget totals divided into basic research, applied research, and development. The allocation of agency budgets among these three categories is not an exact procedure. A certain arbitrariness is inevitably involved and the best we can hope for is consistency within each agency's budget. For example, both NASA and, to a lesser extent, DOD have changed the bases on which they allocate funds to the basic research category, and NASA's changes have forced NSF to adjust the prior-year totals in its statistical reports.[1] At NIH, difficulties arise because of the diversity of definitions used for "basic," "applied," and "development," in the medical field. By applying NSF's definitions to the total NIH budget, the Institute feels it can obtain representative, although not precise, data for the three R&D categories, but that at the individual institute level a comparable breakdown of the budget would have little meaning. Further, there is the problem that the figures are compiled under severe time pressures. This year, for example, re-consideration by DOD after the documents went to press resulted in a shift of approximately $400 million from development to applied research. Our figures show these changes, and therefore differ from those in "Special Analysis P" and the "OMB Data for Special Analysis P."

[1] See AAAS-77, pp. 29 and 67.

With these qualifications in mind, look at the totals and trends. In current dollars, all three categories have received increases since FY 1972. In constant dollars, applied research and development have increased by 10 percent and 7 percent, respectively, between FY 1972 and 1978, while basic research is back to its FY 1972 level after an intervening decline. Between FY 1972 and 1976, constant dollars for applied research and development also decreased, but these areas have recovered more rapidly than basic research. In the FY 1978 budget, the intent seems to be to allow basic research and development to enjoy some of the increases given to applied research in past years. Basic research shows a real growth of 5.3 percent; development continues the growth begun around 1974 by increasing 9.3 percent in constant dollars; and applied research shows only a 2.4 percent increase in "real" terms. The reader may recall that basic research and development were mentioned in the President's Budget Message, while applied research was not.

3. R&D for Selected Functions

Some of the special analyses of the Ford FY 1978 budget and some of the papers in *Issues '78* include statistical crosscuts showing the total amounts for R&D related to various functions. In Table 7 we present these R&D funding statistics for health, environment, energy, education, and earthquake hazards. Each functional analysis is intended to include all relevant activities without requiring that an activity be assigned to only one function. Thus, the totals presented in Table 7 are not additive and overlap when the same R&D program serves several functions.

The trends in health research and environmental R&D are similar—large increases from FY 1975 to 1976 with a leveling off in constant dollars after FY 1976. Environmental R&D stays almost even in constant dollars, while health research gets a 2.6 percent increase in FY 1978. In the health area, the outlay pattern is still being affected by the impoundment of funds in 1973–74. Energy continues to be a big gainer, increasing by almost 18 percent in constant dollars in FY 1978. Nuclear R&D grows at a rate more than one and one-half times that of non-nuclear programs. Of the functions shown in Table 7, only energy has been significantly changed by President Carter's amendments, the net effect of which was a reduction of almost $9 million in outlays in FY 1978. This compares with about a $100 million decrease in budget authority, as will be seen in the subsequent discussion of agency R&D budgets. Education research shows large, steady increases since FY 1976 after a large decrease; these apparent trends must be treated with caution, however, because of the special difficulties in compiling data for education research and the further complications caused by program consolidation proposals and counter proposals that have been a central theme in education for the past several years. Recent trends in education research are more fully discussed in the reports of the National Institute of Education.

As a special initiative, the FY 1978 budget provides the first year of an increased level of funding for a multi-year effort intended to mitigate earthquake hazards during the 1980's. This goal is to be pursued through the development of reliable prediction capabilities along with

Table 7. R&D Outlays for Selected Functions (in millions)

	FY 1975 Actual	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget
Health Research[1]				
TOTAL (ex-facilities), current dollars	$2,459	$3,095	$3,301	$3,592
Same, constant 1972 dollars	(1,971)	(2,348)	(2,343)	(2,405)
Environmental R&D Activities[2]				
Pollution Control and Abatement	$ 570	$ 724	$ 778	$ 800
Understanding, Describing, and Predicting	592	867	933	1,010
TOTAL, current dollars	$1,162	$1,591	$1,711	$1,810
Same, constant 1972 dollars	(931)	(1,207)	(1,214)	(1,212)
Energy R,D&D Activities[3]				
Non-nuclear R&D	$ 276		$ 906	$1,072
Nuclear R&D	856		1,508	1,970
TOTAL Direct Energy R&D	$1,132		$2,414	$3,042
Supporting Energy R&D	405		513	613
TOTAL, current dollars	$1,537	$2,165Est.[3]	$2,927	$3,655
Same, constant 1972 dollars	(1,232)	(1,643)	(2,077)	(2,447)
Education Research[4]				
TOTAL, current dollars	$ 416	$ 326	$ 462	$ 580
Same, constant 1972 dollars	(333)	(247)	(328)	(388)
Major Earthquake Hazard Reduction Programs[5]				
Geological Survey			$ 11	$ 28
NSF			12	26
TOTAL, current dollars			$ 23	$ 54
Same, constant 1972 dollars			(16)	(36)

[1] "Special Analysis K," FY 1977 and FY 1978 Budgets and AAAS–77.
[2] "Special Analysis Q," FY 1977 and FY 1978 Budgets and AAAS–77.
[3] *Issues '78*, FY 1978 Budget and AAAS–77. Actual data for FY 1976 are not included in the table in *Issues '78*. The estimated total from AAAS–77 is shown.
[4] "Special Analysis I", FY 1977 and FY 1978 Budgets. For a more thorough analysis of education R&D, see, *R&D System Studies*, Technical Reports #1 and #2, National Institute of Education, 1977.
[5] *Issues '78*, FY 1978 Budget.

an examination of their social, economic, and legal implications; risk assessments by geographic region; codes and standards for earthquake resistant structures; and more effective management techniques for earthquake preparedness and utilization of research results. The major efforts are to be conducted or sponsored by the Geological Survey and NSF, each of which would more than double its funding in this area under the budget proposals. Even in constant dollars, the total effort would more than double in FY 1978, and a further increase of about 30 percent in current dollars is planned for FY 1979. While the coordinated efforts are proceeding in NSF and USGS, OMB plans to lead an interagency study to determine whether related programs in other agencies should be better coordinated or reorganized.

The background to the decision to step up earthquake research is worth describing briefly as an example of how a policy initiative in R&D got into the budget. The potential for major disasters has been widely recognized in recent years because of many disasters and near disasters around the world, but especially interesting in the context of this report is the role played by earthquake research scientists and the process of interaction between the government and the scientific community. The specific impetus appears to have come from the feelings of research scientists that a reliable prediction capability can be developed within 10 years. These views were formalized in a report by an advisory panel to the President's Science Adviser in September 1976 which was consistent with an earlier study by the former President's Science Advisory Committee. The advisory panel developed a comprehensive plan covering about six research areas with three alternative levels of funding proposed for each, with results one could expect from each funding level specified. The plan which appeared in the administration's budget was based on the intermediate alternative. This case illustrates one mechanism that was successful in translating inputs by the scientific community into new initiatives supported in the federal budget.

4. Social Science R&D

The federal role in the support of social science R&D is the subject of much debate. Many questions find their way into this debate, including: What is the current capacity of the social science R&D community for conducting R&D? Is the federal government overinvesting (or underinvesting) in social science R&D? What kinds of social science R&D does the government support? What types of social science R&D should the government support (or not support)? Two studies conducted by the National Academy of Sciences/National Research Council on the role of social science in NSF and on the social science R&D supported throughout the federal government shed light on some of these questions. Our purpose here is not to enter the debate, but only to show the approximate size of the social science R&D domain in the current budget. Estimates are shown in Table 8 for both FY 1977 and FY 1978. We must

emphasize that the data are only estimates, and that our main purpose is to show the components of the domain, not evaluate totals, trends, or substance.

As defined by the NAS study, research is systematic, intensive study directed toward fuller scientific knowledge or understanding of the subject studied. Social science research includes basic, applied or policy research on either the behavior of individuals, groups, or institutions or the effects of policies, programs, or technologies upon behavior. Development includes demonstrations and curriculum development. Excluded are statistics, program evaluation, and dissemination activities. Table 8 reflects these definitions and shows both the diversity of agencies and programs that support social science R&D and the major role of the large mission agencies in this area. In large part, the social science

Table 8. Estimated Federal Support for Social Science R&D[1, 2] (in millions)

	FY 1977	FY 1978
Department of Health, Education, and Welfare		
National Institutes of Health[3]	$ 37	$ 37
Alcohol, Drug Abuse, and Mental Health	154	146
Health Services Administration	12	10
Health Resources Administration	37	32
Assistant Secretary for Education	13	18
Office of Education	157	140
National Institute of Education	70	109
Office of Human Development	73	68
Social Security Administration	20	23
Social and Rehabilitation Service	9	9
Assistant Secretary for Planning and Evaluation	20	22
Department of Agriculture		
Statistical Reporting Service	$ 1	$ 1
Economic Research Service	27	29
Farmer Cooperative Service	3	3
Forest Research	13*	17*
Cooperative State Research Service	29	31
Department of Commerce		
Bureau of Census	$ 3	$ 3
Bureau of Economic Analysis	13	14
Economic Development Administration	15	10
Office of Minority Business Enterprise	2	2
National Bureau of Standards: Experimental Technology Incentives Program	5*	5*
Department of Defense (R&D on Human Resources)[3]	$ 50	$ 50
Department of Justice		
Bureau of Prisons: National Institute of Corrections	$ 5	$ 10
Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice	27	23

R&D supported by the federal government has a distinctively applied nature, focused as it is on the societal problems that are the concern of the agencies supporting the work. Also apparent from Table 8 is the difficulty in identifying many social science R&D programs from the budget alone. The interested reader should consult the more detailed surveys in the NAS reports and in the two National Institute of Education reports that deal with education R&D.

5. *Relation of R&D to Total Federal Budget and GNP*

The final table in this section displays the trends in the relationship of the total federal outlays for R&D to the total federal budget and to the Gross National Product. Data from both the Ford budget and the Carter revisions are included. Table 9 shows that between FY 1972 and 1977, outlays for R&D declined as a percentage of total federal outlays from over 7 percent to under 6 percent, reflecting the fact that the non-R&D

Table 8 *(continued)*

	FY 1977	FY 1978
Department of Labor (includes Employment and Training Assistance and OSHA primarily)	$ 35	$ 35
Department of Housing and Urban Development	$ 55	$ 60
Department of State	$ 2	$ 3
Department of Transportation[3]	$ 50	$ 50
Agency for International Development	$ 27	$ 42
Energy Research and Development Administration[3]	$ 18	$ 18
Environmental Protection Agency[3]	$ 12	$ 12
National Science Foundation		
Biological, Behavioral, and Social Sciences	$ 39	$ 45
Science Education Development and Research	11	8
Scientific, Technological and International Affairs	8	8
RANN	32	33
TOTAL Estimated Social Science R&D[4]	$1,084	$1,127

Source: "OMB Data for Special Analysis P" and *Budget Appendix*.

[1] We are grateful to Mark Abramson, Research Associate, Study Project on Social Research and Development, NAS, for his help in compiling this table.

[2] All amounts are estimates of Budget Authority except those indicated with an asterisk (*) which are costs.

[3] Social Science R&D is supported by programs throughout these agencies. The amounts shown are from the NAS data for FY 1977; for the purposes of our estimates, the same amount is used for FY 1978.

[4] Other agencies supporting some social science R&D, but for which data are not readily available are: Agricultural Research Service; National Oceanic and Atmospheric Administration; Center for Disease Control; Department of Interior, largely the National Park Service.

Table 9. Federal R&D, Total Budget, and GNP (in billions)*

	FY 1972 Actual	FY 1975 Actual	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget
Total Federal R&D Outlays	$ 16.7	$ 19.6	$ 21.1	$ 23.6	$ 26.6 (26.4)
Total Federal Budget Outlays	$ 232.0	$ 326.1	$ 366.5	$ 411.2 (417.4)	$ 440.0 (459.4)
R&D as Percent of Total Budget	7.2%	6.0%	5.8%	5.7% (5.7%)	(6.0%) (5.7%)
Gross National Product	$1,110.5	$1,450.6	$1,609.5	$1,827.6 (1,830.2)	$2,038.4 (2,047.8)
R&D as Percent of GNP	1.5%	1.4%	1.3%	1.3% (1.3%)	1.3% (1.3%)

Source: *The Budget*, Ford Budget and Carter Revisions; "OMB Data for Special Analysis P," Ford Budget and Revised; *Federal Funds*, Volume XXV, NSF.
* Carter revisions shown in parentheses.

areas in the budget grew faster during this period than did R&D. Ford's estimates for FY 1978 show an increase in the percentage of R&D in the total budget. Carter's adjustments—a smaller increase in R&D and the economic stimulus packages—result in R&D remaining at the same relative level in the budget as in FY 1977. As a percentage of GNP, outlays for R&D decreased from 1.5 percent to 1.3 percent from FY 1972 to 1976, but in both the Ford budget and the Carter revisions it would stay at 1.3 percent through FY 1978.

C. Whither Basic Research?

Support for basic research was a primary concern of the Ford administration throughout the process of preparing the FY 1978 budget. At OMB, the staff was given specific policies to follow in determining the support for basic research. Some involved in this process have gone as far as to say that basic research was examined more closely this year than in the past decade. This special attention at staff and agency levels is reflected throughout President Ford's Budget Documents. As we have seen, his message to Congress accompanying the budget stated that he

was again proposing real growth for basic research (and development) because he was convinced that "we must maintain our world leadership in science and technology in order to increase our national productivity and attain the better life we want for our people and the rest of the world." As emphasized again and again – in the section on the General Science, Space, and Technology function, in "Special Analysis P," and *Issues '78* – the President wanted one of his major legacies on leaving office to be a strong recommendation for real growth in federal support for basic research in FY 1978, growth that would continue the reverse of the 8-year trend from 1967 to 1975 when federal support for basic research declined by about 20 percent in real terms.

How much basic research growth does the budget propose? The answer depends on how one plays the numbers game; that is, which budget statistics one uses. The possible answers are: 11.3 percent in budget authority; 9.2 percent in obligations; and 12.1 percent in outlays. Using the Ford administration's rate of inflation of 6 percent, the corresponding amounts of real growth would be 5.3 percent, 3.2 percent, and 6.1 percent. Our analysis will be in terms of budget authority, which is the best indicator of the administration's intent for FY 1978 and the least distorted by estimating anomalies.

President Carter made only minimal changes in President Ford's request for the support of basic research. The $5 million increase for the National Institute of Child Health and Human Development would include some basic research, but the changes in Defense and NASA did not significantly affect basic research and the NSF budget was completely unchanged. The fact that President Carter made no significant changes in the FY 1978 budgets for basic research does not necessarily imply his administration's support of them or of the growth policy on which they were based. In the time Carter had to submit his amendments to Ford's budget, it would have been impossible to undertake a thorough review of support for basic research, and he had not completed the selection of his own scientific team. It is also likely that, as noted by H. Guyford Stever, the support for basic research in the scientific community is so strong that Carter would undoubtedly get the same advice as his predecessor on the need and importance of increased funding in this area.

As can be seen in Table 10, the FY 1978 budget would provide real growth for basic research in all the major R&D agencies. Looking back over the past 11 years, we see that basic research in some agencies had fallen on particularly hard times. Even in current dollars, funding for basic research in ERDA, NASA, and Defense declined from 1967 to 1975. The decline is much more pronounced in terms of constant dollars as shown in Table 11. In this context only NSF has managed a continual increase in its support of basic research from 1967 to the present. From 1967 to 1975, funds for basic research in other (mission) agencies, except HEW, decreased; support by HEW remained about constant. Total support for basic research in constant dollars decreased by 20.6 percent

Table 10. Conduct of Basic Research by Agency in Current Dollars (Budget Authority in millions)

	FY 1967[1] Actual	FY 1972[1] Actual	FY 1975[1] Actual	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget	%Change FY 1977 to 1978
HEW	$ 372	$ 461	$ 592	$ 658	$ 733	$ 793	+8.3%
NSF	239	368	486	541	612	688	+12.5%
ERDA[2]	302	268	247	348	389	427	+9.8%
NASA	328	332	242	293	320	365	+14.3%
Defense	284	270	236	250	276	324	+17.7%
Agriculture	100	137	154	176	193	215	+11.5%
Interior[3]	–	–	–	121	127	143	+12.8%
Commerce[3]	–	–	–	21 203	25 217	24 234	−2.0%
EPA[3]	–	–	–	17	17	16	−8.0%
Other	103	139	189	44	48	51	+5.4%
TOTAL Basic Research, current dollars	$1,728	$1,975	$2,146	$2,469	$2,738	$3,047	+11.3%

Source: "OMB Data for Special Analysis P" and *Federal Funds*, Volume XXV, NSF.
Note: Due to rounding, detail may not add to total and percentages may not correspond exactly to the differences in the table.
[1] Budget Authority figures are not available for FY 1967, 1972, and 1975. Data shown are authors' estimates based on obligation data.
[2] Data for FY 1967 and 1972 are reported under the Atomic Energy Commission.
[3] For FY 1967, 1972, and 1975, this agency is included in "Other."

Table 11. Conduct of Basic Research by Agency in Constant 1972 Dollars (Budget Authority in millions)

	FY 1967[1] Actual	FY 1972[2] Actual	FY 1975[1] Actual	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget
HEW	$ 466	$ 461	$ 474	$ 499	$ 520	$ 531
NSF	299	368	390	411	434	461
ERDA[2]	378	268	198	264	276	286
NASA	411	332	194	222	227	244
Defense	356	270	189	190	196	217
Agriculture	125	137	123	134	137	144
Interior[3]	–	–	–	92	90	96
Commerce[3]	–	–	–	16 } 154	18 } 154	16 } 157
EPA[3]	–	–	–	13	12	11
Other	129	139	151	33	34	34
TOTAL Basic Research, 1972 dollars	$2,164	$1,975	$1,719	$1,874	$1,944	$2,040

[1] Budget Authority figures are not available for FY 1967, 1972, and 1975. Data shown are authors' estimates based on obligation data.
[2] Data for FY 1967 and 1972 are reported under the Atomic Energy Commission.
[3] For FY 1967, 1972, and 1975, this agency is included in "Other."

over this period. In the same period, support for applied research increased by 3.3 percent in constant dollars. As the concern with "relevancy" affected so many facets of our society during these years, so, too, did it affect the funding patterns of the large federal R&D agencies, particularly the mission agencies.

The decline in basic research support seems to have bottomed out in FY 1975. From FY 1975 to 1978 an overall increase of 18.7 percent is projected in constant dollars, with a larger increase proposed for FY 1978 than is estimated for FY 1977. Even with these recent increases, however, the level proposed for FY 1978 is still below that in FY 1967 in constant dollars. And the FY 1978 level is by no means certain. Congressional action will undoubtedly affect the proposed increases. Judging from actions in previous years, we might expect some reductions in NSF and an increase in HEW, principally NIH. The proposed increases in Agriculture and Interior are related to food production and earthquakes, respectively; programs that Congress might be expected to favor.

The conceptual and statistical problems with budget figures for basic research noted in AAAS-77 continue to plague the data available for FY 1978. The large apparent growth for basic research in NASA may be partly a statistical fluke. Some of the spacecraft and space missions are exclusively for basic scientific research. However, there are problems in determining how much, if any, of the costs of these activities should be counted as basic research, and these problems do not appear to have been resolved in a consistent manner. Another statistical problem in estimating basic research (as noted in AAAS-77, p. 67), the labeling of the entire DOD "6.1-Research" category as basic research, seems to have been corrected in the current budget.

What will be the effects of the FY 1978 budget increases for basic research on the nation's colleges and universities? Unfortunately, although this sector is the primary performer of basic research, for both the federal government and the nation as a whole, the FY 1978 budget materials do not provide a direct answer. They do, however, provide estimates of the total amounts of R&D expected to be performed at colleges and universities (see Table 12). While large increases in support of R&D at academic institutions are projected for some agencies, total funding will remain at about the same level as in FY 1977 after allowing for inflation. Since FY 1967, federal support for R&D at colleges and universities has grown unevenly in constant dollars, increasing some years, decreasing in others. Between 1967 and 1975, there has been an overall growth of 5.8 percent in "real" terms.

Considering the projected increase of 11.3 percent in budget authority for all basic research and the leading role of colleges and universities in this area, it would appear that the FY 1978 budget will provide a growth in federal support for academic basic research that is greater than the projected 6.6 percent growth rate for all R&D. In the absence of estimates by others, we will go out on a limb and make a "guessti-

mate." NSF statistics for past years show that 49.3 percent of federal support for basic research went to colleges and universities in fiscal years 1976 and 1977. If this percentage holds in FY 1978, the growth rate from FY 1976 to FY 1978 for basic research in academic institutions would be the same as for all basic research, 11.3 percent. While this may be a coincidence in the figures, the "guesstimate" suggests a growth rate from FY 1977 to FY 1978 in the federal support for basic research at colleges and universities almost 5 percent greater than the growth in federal support for all R&D at these institutions. Since federally sup-

Table 12. Support for Conduct of R&D at Colleges and Universities (Budget Authority in millions)

	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget	% Change FY 1977 to 1978
Current dollars:				
HEW	$1,472	$1,696	$1,706	+.6%
NSF	445	496	562	+13.1%
Defense	291	312	340	+8.7%
ERDA	146	170	223	+31.4%
Agriculture	125	141	169	+19.9%
NASA	119	117	120	+2.6%
EPA	38	38	36	−5.3%
Interior	32	31	34	+9.7%
Commerce	31	32	29	−8.8%
AID	13	14	29	+102.1%
Transportation	20	20	24	+19.9%
Other	21	22	24	+9.5%
TOTAL	$2,755	$3,090	$3,295	+6.6%
Constant 1972 dollars:				
HEW	$1,117	$1,204	$1,142	−5.1%
NSF	338	352	376	+6.8%
Defense	221	221	228	+3.2%
ERDA	111	121	149	+23.1%
Agriculture	95	100	113	+13.0%
NASA	90	83	80	−3.6%
EPA	29	27	24	−11.1%
Interior	24	22	23	+4.5%
Commerce	24	23	19	−17.4%
AID	10	10	19	+90.0%
Transportation	15	14	16	+14.3%
Other	16	16	16	
TOTAL	$2,089	$2,193	$2,206	+.6%

Source: Current dollar figures are from "OMB Data for Special Analysis P."
Note: Due to rounding, detail may not add to total and percentages may not correspond exactly to the differences in the table.

ported R&D at these institutions is approximately 50 percent basic research, 40 percent applied research (primarily medical), and 10 percent development, an increase of about 11 percent in basic research within an overall increase of about 6 percent would mean only a 1 percent increase in applied research and development. If our assumptions are correct, the academic community as a whole can look forward to real growth of perhaps 5 percent in federally supported basic research at their institutions and a reduction of almost the same amount in applied research and development. A corollary from the same assumptions and analysis would be that the projected 11.3 percent increase in basic research in FY 1978 will be shared equally between colleges and universities on one hand, and government and industry research organizations on the other. All of this is only speculation, however, and the actual distribution of R&D funds may turn out to be different than that in previous years. One view might be that the increased emphasis on basic research will result in greater relative support to colleges and universities than to government and industry. But the pressures being put on NSF and NIH by industry and Congress to increase industry eligibility for competive basic research grants suggests the equally plausible position that the balance will shift slightly toward industry. And maybe everything will stay the same. We'll know more about all this a year from now.

D. Agency R&D Budgets

We now will analyze the basic building blocks of the R&D budget totals—the R&D budgets of some of the individual agencies. We will try to explain some of the nuances, caveats, and necessary qualifications in the budget statistics, and attempt to provide a general overview of the program content of some of the larger R&D agencies. Our discussion is based on information in "Special Analysis P," *Issues '78*, and agency Congressional budget justifications and, in some cases, on conversations with agency officials and others in the administration. We only scratch the surface, for we do not pretend to have examined the mountains of materials available or to have kept up with Congressional developments; but we can at least give a summary view of the major features of the R&D budgets of some of the principal agencies.

First we will paint a broad-brush picture of the R&D totals by agency, using the figures that tie in to the totals previously discussed. We will then turn to the individual agencies, where our statistics and analyses will be based primarily on the agencies' budget justifications. In some cases, the figures will not correspond directly or at all to statistics included in the Budget Documents or the NSF reports; this reflects the fact that R&D frequently is not managed or budgeted by the agencies in the same categories used by OMB and NSF for statistical purposes. After our look at the agency budgets and policies for FY 1978, we will be

prepared to consider, in Chapter 4, what might be in store for R&D and some of the principal R&D agencies during the next 5 years.

1. Agency Totals

The composition by agency of the totals for R&D in the FY 1978 budget is shown in Tables 13, 14 and 15 by budget authority, outlays, and obligations, respectively. The R&D universe as defined by OMB excludes some agencies with R&D related activities, such as the White House Office of Science and Technology Policy ($3.2 million) and the Office of Technology Assessment ($8.5 million). As noted in the Budget Documents, two kinds of R&D support also are excluded from the table: tax savings to industry through special tax law provisions for R&D (estimated at $1.5 billion in FY 1978), and allowances associated with procurement contracts to private industry for performing "Independent R&D."

Referring to Table 13, we see that total budget authority for R&D in Ford's FY 1978 budget is estimated at $28.0 billion; $26.4 billion for conduct of R&D and $1.6 billion for R&D facilities. Under Carter's amendments these estimates become $27.7 billion, $26.3 billion, and $1.4 billion, respectively.

Now let us look more closely at the trends in R&D support shown by the budget figures. To try to sort out real trends from the effects of inflation we shall assume an inflation rate of 6 percent for FY 1978, approximately the same rate assumed in both the Ford and Carter budgets. Since there really isn't any accurate way to gauge the impact of inflation on R&D budgets (see AAAS-77, Chapter 2), we will assume that any R&D increase of more than 7 percent is a "real" increase, and that anything less than a 5 percent increase is a "real" cut; increases between 5 and 7 percent will be regarded as "level."

We see, then, that in total, R&D gets a "real" increase of 3.8 percent (Carter: 2.5 percent); in "real" terms, the total conduct of R&D increases by 4.3 percent (Carter: 3.7 percent); while the total for R&D facilities decreases by 1 percent (Carter: 12.8 percent). In conduct of R&D, five of the major agencies show "real" increases: Defense, ERDA, NSF, Agriculture, and Transportation; four would receive "real" decreases: HEW, Interior, EPA, and Commerce; and NASA remains about level. Noteworthy large "real" increases are also shown for NRC and AID, although the significance of the percentages for these smaller agencies may be questionable. The FY 1978 budget projects a stronger upward trend in R&D than the FY 1977 budget. More of the major agencies are given "real" increases and fewer get "real" decreases. Further, even excluding the major agencies showing "real" increases, the combined total of the other agencies would increase by 5.1 percent in current dollars, and thus remain about level in "real" terms. Thus, the FY 1978 budget provides a real boost in conduct of R&D for five of the major agencies and, on the average, the other agencies hold their own.

The R&D facilities totals for budget authority reflect a large decrease, chiefly because the FY 1977 figures included full funding for the $400 million new Air Force aircraft engine test complex. This decrease is only partially offset by increases for ERDA energy R&D and demonstra-

Table 13. Research and Development in the FY 1978 Budget by Agency (Budget Authority in millions)

Budget Authority	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget*	% Change FY 1977 to 1978*
Total Conduct of R&D[1]	$21,221	$23,751	$26,425	+11.3%
			(26,287)	(+10.7%)
Total R&D Facilities[1]	834	1,561	1,623	+4.0%
			(1,440)	(−7.8%)
TOTAL R&D[1]	$22,055	$25,312	$28,048	+10.8%
			(27,727)	(+9.5%)
Conduct of R&D				
Defense-Military Functions[1]	$ 9,902	$10,929	$12,450	+13.9%
			(12,198)	(+11.6%)
ERDA	2,644	3,482	4,064	+16.7%
			(4,143)	(+19.0%)
NASA	3,447	3,583	3,833	+7.0%
			(3,848)	(+7.4%)
HEW	2,574	2,897	2,973	+2.6%
			(2,986)	(+3.1%)
NSF	617	693	766	+10.5%
Agriculture	482	528	579	+9.5%
Transportation	309	312	357	+14.5%
Interior	324	338	352	+4.1%
EPA	270	264	266	+.7%
Commerce	224	246	252	+2.3%
Nuclear Regulatory Commission	98	122	148	+21.6%
Veterans	101	109	112	+2.9%
HUD	53	55	60	+9.0%
AID	24	27	42	+54.6%
Labor	29	35	36	+1.1%
Justice	42	42	36	−16.3%
			(40)	(−6.8%)
Smithsonian	26	30	32	+5.2%
Corps of Engineers	26	25	27	+11.4%
TVA	8	10	11	+15.8%
Treasury	4	5	7	+39.6%
Consumer Product Safety Commission	4	4	4	−22.2%
Library of Congress	3	3	3	+9.7%
State	1	2	3	+86.7%

Table 15 *(continued)*

Budget Authority	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget[a]	% Change FY 1977 to 1978[a]
ACDA	1	2	3	+8.3%
Civil Service Commission	4	4	2	−47.6%
FCC	2	2	2	
Advisory Committee on Intergovernmental Relations	1	1	2	+7.1%
GSA	[b]	[b]	2	+650.1%
FTC	1	1	1	
(All Other)			(2)	
TOTAL, Conduct of R&D	$21,221	$23,751	$26,425	+11.3%
			(26,287)	(+10.7%)
R&D Facilities				
ERDA	$ 425	$ 625	$ 1,014	+62.2%
			(829)	(+32.6%)
Defense-Military Functions[c]	165	584	233	−60.1%
NASA	82	118	162	+37.0%
NSF	52	39	47	+21.3%
HEW	28	136	116	−14.8%
Transportation	13	17	22	+33.9%
Agriculture	36	12	14	+25.0%
Commerce	7	5	7	+32.0%
Veterans	13	9	4	−52.3%
Justice	3	4	2	−56.0%
			(4)	(0.0%)
EPA	3	2	1	−47.6%
Smithsonian	[b]	[b]	1	+25.0%
TVA	1	1	[b]	−50.0%
Interior	1	9		
Nuclear Regulatory Commission	5			
TOTAL, R&D Facilities	$ 834	$ 1,561	$ 1,623	+4.0%
			(1,440)	(−7.8%)
TOTAL R&D	$22,055	$25,312	$28,048	+10.8%
			(27,727)	(+9.5%)

Source: "OMB Data for Special Analysis P," Ford Budget and Revised.
Note: Due to rounding, detail may not add to total and percentages may not correspond exactly to the differences in the table.
[a] Carter revisions shown in parentheses. Budget Authority estimated from obligation data.
[b] Less than $0.5 million.
[c] These amounts differ slightly from the "OMB Data for Special Analysis P" because of updated figures for Defense. The changes in Budget Authority have been estimated from the reported changes in Obligations.

tion facilities, for additional increments of space shuttle facilities for NASA, and for synchrotron radiation facilities at ERDA and NSF.

Our analysis has been in terms of budget authority rather than the

Table 14. Research and Development in the FY 1978 Budget by Agency (Outlays in millions)

Outlays	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget*	% Change FY 1977 to 1978*
Total Conduct of R&D[1]	$ 20,271	$ 22,586	$ 25,269	+11.9%
			(25,182)	(+11.5%)
Total R&D Facilities[2]	784	970	1,294	+33.4%
			(1,221)	(+25.9%)
TOTAL R&D[3]	$ 21,055	$ 23,556	$ 26,563	+12.8%
			(26,403)	(+12.1%)
Conduct of R&D				
Defense-Military Functions[4]	$ 9,364	$ 10,404	$ 11,934	+14.7%
			(11,765)	(+13.1%)
ERDA	2,225	3,168	3,735	+17.9%
			(3,798)	(+19.9%)
NASA	3,521	3,557	3,745	+5.3%
			(3,757)	(+5.6%)
HEW	2,566	2,532	2,799	+10.6%
			(2,803)	(+10.7%)
NSF	623	650	724	+11.4%
Agriculture	460	544	573	+5.3%
Transportation	303	336	336	−0.3%
Interior	315	342	351	+2.7%
EPA	251	313	277	+11.5%
Commerce	224	243	258	+5.8%
Nuclear Regulatory Commission	81	114	138	+21.4%
Veterans	97	108	112	+3.1%
HUD	54	59	60	+1.7%
AID	23	24	32	+35.3%
Labor	24	34	35	+1.5%
Justice	48	46	41	−10.9%
			(42)	(−8.7%)
Smithsonian	28	30	31	+2.3%
Corps of Engineers	25	24	27	+11.5%
TVA	49	32	31	−1.3%
Treasury	3	5	7	+39.6%
Consumer Product Safety Commission	3	5	3	−28.3%
Library of Congress	3	3	3	+3.1%
State	1	2	3	+86.7%
ACDA	2	2	2	−4.2%

Table 14 *(continued)*

Outlays	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget*	% Change FY 1977 to 1978*
Civil Service Commission	4	4	3	−23.8%
FCC	1	2	2	−17.4%
Advisory Committee on Intergovernmental Relations	2	2	2	−11.8%
GSA	*	*	2	+650.0%
FTC	1	1	1	
(All Other)			(2)	
TOTAL, Conduct of R&D	$ 20,271	$ 22,586	$ 25,269	+11.9%
			(25,182)	(+11.5%)
R&D Facilities				
ERDA	$ 370	$ 473	$ 670	+41.7%
			(598)	(+26.4%)
Defense-Military Functions[1]	141	166	310	+86.6%
NASA	120	125	132	+5.9%
NSF	50	37	45	+23.7%
HEW[2]	45	68	70	+2.9%
Transportation	12	20	19	−7.4%
Agriculture	9	35	23	−35.7%
Commerce	8	6	5	−7.0%
Veterans	3	10	8	−10.5%
Justice	1	2	4	+100.0%
			(3)	(+50.0%)
EPA	7	4	5	+17.8%
Smithsonian	*	1	1	
TVA	16	13	*	−96.9%
Interior	1	8	1	−85.9%
Nuclear Regulatory Commission	1	2	1	−52.0%
TOTAL, R&D Facilities[2]	$ 784	$ 970	$ 1,294	+33.4%
			(1,221)	(+25.9%)
TOTAL R&D	$ 21,055	$ 23,556	$ 26,563	+12.8%
			(26,403)	(+12.1%)

Source: "OMB Data for Special Analysis P," Ford Budget and Revised.
Note: Due to rounding, detail may not add to total and percentages may not correspond exactly to the differences in the table.
* Carter revisions shown in parentheses.
* Less than $0.5 million.
[1] These amounts differ slightly from "Special Analysis P" because of updated figures for Defense. The changes in Outlays have been estimated from the reported changes in Obligations.
[2] These amounts differ from "Special Analysis P" because of updated figures for HEW.

more customary obligations. Comparison of the trends and estimates in the tables for some of the leading agencies will indicate some of the distortions apparent in the obligations figures:

(1) NASA FY 1977 obligations figures seem overstated by as much as $200 million; the detailed budget schedules assume a zero

Table 15. Research and Development in the FY 1978 Budget by Agency
(Obligations in millions)

Obligations	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget*	% Change FY 1977 to 1978*
Total Conduct of R&D[1]	$ 20,731	$ 24,477	$ 26,340	+7.6%
			(26,202)	(+7.0%)
Total R&D Facilities[2]	801	1,574	1,706	+8.4%
			(1,523)	(−3.2%)
TOTAL R&D[1]	$ 21,532	$ 26,051	$ 28,046	+7.7%
			(27,725)	(+6.4%)
Conduct of R&D				
Defense-Military Functions[1]	$ 9,629	$ 11,147	$ 12,333	+10.6%
			(12,081)	(+8.4%)
ERDA	2,499	3,610	4,064	+12.6%
			(4,173)	(+15.6%)
NASA	3,488	3,800	3,833	+0.9%
			(3,848)	(+1.3%)
HEW	2,543	2,910	2,976	+2.3%
			(2,989)	(+2.7%)
NSF	617	693	766	+10.5%
Agriculture	466	530	579	+9.2%
Transportation	274	367	359	−2.2%
Interior	322	349	355	+1.7%
EPA	221	311	266	−14.5%
Commerce	228	247	250	+1.2%
Nuclear Regulatory Commission	94	122	148	+21.6%
Veterans	103	116	118	+1.7%
HUD	61	55	60	+9.0%
AID	24	27	42	+54.6%
Labor	26	35	36	+1.1%
Justice	44	45	36	−20.9%
			(40)	(−12.0%)
Smithsonian	26	31	32	+4.2%
Corps of Engineers	26	25	27	+11.4%
TVA	19	32	31	−1.3%
Treasury	3	5	7	+39.6%
Consumer Product Safety Commission	4	4	4	−2.2%
Library of Congress	3	3	3	+9.7%

Table 15 *(continued)*

Obligations	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget*	% Change FY 1977 to 1978*
State	1	2	3	+86.7%
ACDA	1	2	3	+8.3%
Civil Service Commission	4	4	2	−47.6%
FCC	2	2	2	
Advisory Committee on Intergovernmental Relations	2	2	2	−6.2%
GSA	#	#	2	+650.0%
FTC	1	1	1	
(All Other)			(2)	
TOTAL, Conduct of R&D	$ 20,731	$ 24,477	$ 26,340	+7.6%
			(26,202)	(+7.0%)
R&D Facilities				
ERDA	$ 412	$ 681	$ 1,014	+48.8%
			(829)	(+21.7%)
Defense-Military Functions[1]	140	467	346	−25.9%
NASA	94	146	161	+10.9%
NSF	52	39	47	+21.3%
HEW[2]	28	143	85	−40.6%
Transportation	14	25	22	−13.3%
Agriculture	16	23	15	−35.7%
Commerce	7	7	7	−9.5%
Veterans	12	9	4	−59.8%
Justice	3	4	2	−50.0%
			(4)	(0.0%)
EPA	6	7	2	−72.7%
Smithsonian	1	1	1	−96.8%
TVA	10	13	#	−98.9%
Interior	1	9	#	
Nuclear Regulatory Commission	5			
TOTAL, R&D Facilities[2]	$ 801	$ 1,574	$ 1,706	+8.4%
			(1,523)	(−3.2%)
TOTAL R&D	$21,532	$26,051	$28,046	+7.7%
			(27,725)	(+6.4%)

Source: "OMB Data for Special Analysis P," Ford Budget and Revised.
Note: Due to rounding, detail may not add to total and percentages may not correspond exactly to the differences in the table.
* Carter revisions shown in parentheses.
# Less than $0.5 million.
[1] These amounts differ slightly from "Special Analysis P" because of updated figures for Defense.
[2] These amounts differ from "Special Analysis P" because of updated figures for HEW.

carry-over into FY 1978 for conduct of R&D which is out of line with past experience.

(2) ERDA obligation trends are distorted by a shortfall in FY 1976 and the assumption that much of this carry-over will be obligated in FY 1977; this tends to overstate the budget increase from FY 1976 to FY 1977 and understates the increase from FY 1977 to FY 1978.

(3) The Defense figures also are optimistic on FY 1977 obligations; they assume that higher obligations of carry-over funds will offset the Congressional reductions in FY 1977 budget authority.

(4) HEW presents a confused picture, in outlays as well as obligations. Obligations and budget authority show big jumps from FY 1976 to 1977 and small increases in FY 1978. Outlays show a decrease in FY 1977 and a large increase in FY 1978. These trends are in part the fallout from the impoundment of funds by President Nixon in 1973–74 and the Congressional override of the President's veto of the FY 1976 HEW appropriations bill. Release of the impounded funds for obligations in late FY 1974 has resulted in large increases in outlays in FY 1975 and 1976. The Congressional override midway in FY 1976 caused an increase in obligations into FY 1977, which in turn would increase outlays in FY 1978.

2. R&D in the Department of Defense (DOD)

Defense R&D continues to be by far the nation's largest single R&D enterprise. In dollar terms it receives just under half of the total amounts for R&D in the federal budget. Its importance is emphasized in Presidential budget statements, and its major projects, like the B–1 bomber, the Trident submarines, and cruise missiles, receive wide Congressional and public attention. The level of defense R&D budgets, like the level of the total Defense budget, is itself a major symbol in national policy debates. Those who are alarmed by Soviet progress in weaponry and skeptical of detente tend to favor increases in the overall military R&D budget almost automatically, without reference to the content of the program. Others, more concerned with the continuous spiral of the arms race and perhaps more sanguine on the chances for arms control, tend to challenge new major weapons system developments and ask if reductions in the defense budget would not be possible.

President Ford's FY 1978 budget called for a real increase in Department of Defense R&D of about 6 percent in FY 1978 and projected another large real increase in FY 1979 of around 8 percent. A tough position on Defense became a central theme of the Ford administration after the outcry at Secretary Schlesinger's dismissal in the fall of 1976 and the challenge from the right by Governor Reagan in 1977. The Pentagon and its allies mounted a major campaign to head off possible

drastic cuts in the Congress in the FY 1977 budget. As it turned out, the mood of Congress also changed and its reductions in the defense budget were less than expected; in R&D the DOD was able to take a $420 million cut without changing the planned level of obligations in FY 1977. One cannot help wondering if some "cut insurance" might have been included in the FY 1977 budget. The same unspeakable question haunts the FY 1978 DOD budget. With candidate Carter talking about, and President-elect Carter reaffirming, his intention to make a $5 to $7 billion cut in the defense budget, it is not unthinkable that the military budget planners may have braced the original FY 1978 budget for the expected blow. As events have transpired to date, the Carter budget amendments have made only a 2 percent reduction in the DOD FY 1978 R&D budget, and administration leaders are still explaining their explanations of the President's campaign statements on reducing the total defense budget. The real directions of the Carter administration in military R&D will not become clear until its reviews have been made and its FY 1979 budget put together and released.

The Ford administration left its successors the legacy of a comprehensive statement of its outlook and programs in defense R&D. The final annual statement for Congress of the outgoing Director of Defense Research and Engineering (DDRE), Dr. Malcolm R. Currie, is a 350-page, unclassified book which gives a full statement of his assessment of national needs for military R&D, the United States position vis-à-vis the Soviets in weapons and technology, and the prospects for the future. It contains much information and philosophy on the nature and management of the DOD R&D program. Above all, it is a hard sell for continued real increases in virtually all aspects of defense R&D. The Carter administration probably will not buy all of Dr. Currie's assessments, philosophy, or programs; the new Secretary of Defense, Dr. Harold Brown, is a former Director of Defense Research and Engineering and will undoubtedly place his own stamp on R&D matters. But Currie's statement undoubtedly reflects DOD institutional as well as Ford administration thinking; as such, most of its major thrusts are likely to live on in the new administration.

The tone of the statement and the basic premise of the Ford administration's R&D budget for R&D is stated by Currie on the first page: "I believe that this Nation must maintain a position of unequivocal technological superiority." Everything else follows from this. He renews the call for a strong national commitment backed by a multi-year investment having continuity and real annual growth of at lease 6 to 10 percent. He says the Soviet Union's determined drive toward supremacy in deployed military technology has not abated, and he cites examples of new Soviet systems that have recently appeared. The increases proposed for FY 1978 are intended to allow the DOD "to continue to reverse some dangerously developing trends in the balance of military technology at a time when we can do so most efficiently and at least cost."

The statement places great emphasis throughout on the importance

of maintaining and strengthening the *technology base* which is seen as an essential part of "Group One" R&D activities: the creation and demonstration of options, which then are available if desired for full scale development in "Group Two" R&D activities. R&D associated with the technology base is regarded as consisting of the categories of "research" and "exploratory development" and sometimes also some technology-driven programs in "advanced development"—a total of about $2 billion in the FY 1978 budget. A cardinal point of DOD R&D policy for the last three budgets has been the proposition that DOD budgets for "research" should have an annual real growth rate of 10 percent, and for "exploratory development," 5 percent. The DOD estimates that, through a de facto policy of level funding, the DOD technology base decreased be-

Table 16. Department of Defense Research, Development, Test and Evaluation (RDT&E)[1] (in millions)

Budget Activity	RDT&E Program by Budget Activity				
	FY 1976	FY 197T	FY 1977	FY 1978	FY 1979
Technology Base	$ 1,508.4	$ 384.1	$ 1,680.8	$ 1,879.8	$ 2,073.4
				(1,878.9)	(2,072.4)
Adv. Tech. Dev.	565.5	148.0	636.0	688.4	1,039.5
Strategic Programs	2,235.1	553.5	2,235.3	2,439.5	2,890.5
				(2,269.5)	(2,360.5)
Tactical Programs	2,974.6	756.7	3,650.3	4,408.1	4,827.6
				(4,328.5)	
Intelligence & Communications	948.9	235.7	982.3	1,169.8	1,563.8
				(1,157.8)	
Programwide Mgt. & Spt.	1,287.6	338.6	1,410.9	1,458.0	1,578.4
TOTAL RDT&E	$ 9,520.1	$ 2,416.6	$ 10,595.6	$ 12,043.6	$ 13,973.2
				(11,781.1)	(13,442.2)

Department	RDT&E Program by Component				
	FY 1976	FY 197T	FY 1977	FY 1978	FY 1979
Army	$ 1,970.4	$ 509.5	$ 2,305.1	$ 2,625.7	$ 2,830.6
				(2,532.1)	
Navy	3,314.3	842.4	3,800.4	4,239.1	4,693.4
				(4,229.1)	
Air Force	3,606.0	913.2	3,806.4	4,380.9	5,533.2
				(4,222.9)	(5,003.2)
Defense Agencies	629.4	151.5	683.7	797.9	916.0
				(797.0)	(915.0)
TOTAL RDT&E	$ 9,520.1	$ 2,416.6	$ 10,595.6	$ 12,043.6	$ 13,973.2
				(11,781.1)	(13,442.2)

cause of inflation by almost 45 percent from the mid-sixties to FY 1975. The policy to reverse this trend was supported by Congress in the FY 1976 and FY 1977 budgets. Whether the Carter administration will continue this policy in FY 1979 and in succeeding years remains to be seen.

Table 16 gives a statistical picture of the Research, Development, Test and Evaluations (RDTE) budgets of the DOD, which, together with about $450 million for pay and allowances of military personnel engaged in R&D, makes up the total amounts for the conduct of defense R&D in the overall summaries. Data are given for both FY 1978 and FY 1979, with prior years given for comparison. (The column headed "FY 197T" gives the amounts for the 3-month transition period to the new budget year in 1976.) Breakdowns are shown by category of work, performer, budget activity, and military department. The new budget activity classi-

Table 16 *(continued)*

Category	RDT&E Program by Category				
	FY 1976	FY 197T	FY 1977	FY 1978	FY 1979
Research	$ 327.5	$ 81.9	$ 375.0	$ 419.7	$ 482.9
				(418.8)	(481.9)
Exploratory Dev.	1,180.8	302.2	1,305.8	1,460.1	1,590.5
Advanced Dev.	1,795.3	507.4	1,904.2	2,296.7	3,431.5
				(2,286.7)	
Engineering Dev.	3,620.1	874.6	4,216.7	4,872.5	5,007.7
				(4,632.9)	(4,477.7)
Mgt. & Support	1,253.9	332.9	1,381.0	1,410.1	1,506.8
Oper. Sys. Dev.	1,342.5	317.6	1,412.9	1,584.5	1,953.8
				(1,572.5)	
TOTAL RDT&E	$ 9,520.1	$ 2,416.6	$ 10,595.6	$ 12,043.6	$ 13,973.2
				(11,781.1)	(13,442.2)

Performer	RDT&E by Type of Performer				
	FY 1976	FY 197T	FY 1977	FY 1978	FY 1979
Industry	$ 6,265.4	$ 1,574.3	$ 7,199.3	$ 8,483.3	$ 10,249.2
				(8,220.8)	(9,718.2)
Government					
In-House	2,790.7	727.7	2,895.5	3,011.1	3,121.6
Fed. Contract Res.					
Ctrs. (FCRC)	173.5	44.6	188.9	209.9	232.4
Universities	290.5	70.0	311.9	339.3	370.0
TOTAL RDT&E	$ 9,520.1	$ 2,416.6	$ 10,595.6	$ 12,043.6	$ 13,973.2
				(11,781.1)	(13,442.2)

Source: *Program of Research, Development, Test and Evaluation*, statement by Dr. Malcolm R. Currie.

[1] Carter revisions are noted in parentheses.

fication incorporates the former mission categories—strategic, tactical, etc.—and drops the end-item categories used in previous years; this change is a partial response to recent Congressional requirements and interest in "missionizing" the R&D budget. A few of the highlights of the DOD R&D budget follow:

(1) *Strategic Forces.* The Ford budget called for full steam ahead in completion of B-1 Bomber development, continuation of Trident, Minuteman improvements, M-X mobile ICBM engineering development, and the development of cruise missiles—air, submarine, and surface ship launched. Cruise missiles are seen as the most significant weapons development of this decade. The Carter budget amendments slowed down M-X development with a $160 million cut (from $294 million to $134 million); reallocated $24 million of ship launched cruise missile development funds to get work on the ground launched cruise missile (GLCM) off to a faster start; and reduced work on advanced ballistic reentry systems by $10 million. All these reductions seem to be just holding actions, pending more thorough review.

(2) *General-purpose Forces.* The FY 1978 budget continues DOD's focus on deficiencies in two key potential areas of confrontation: central Europe and the sea lines of communication. The R&D effort is structured to reverse adverse trends in land-warfare systems, maintain the maritime balance, and retain "our clear margin of superiority" in tactical air forces. For land combat, work will continue on a family of air defense weapons against saturation air attack, increased mobility and fire power for the forces, and improved target location capability. For naval forces, anti-submarine warfare, ship defense against cruise missiles, and naval command and control receive R&D emphasis. Tactical air forces R&D will focus on modernization of avionics, ground attack ordnance, and air-to-air missile systems. A major item in the Ford budget was $200 million for the development of the Advanced Attack Helicopter (AAH) for Army battlefield use; this project was cut back to $100 million in President Carter's budget amendments.

(3) *DOD In-house Laboratories.* The DDRE budget statement indicates that DOD is moving toward "block-funding" and increasing the responsibility of DOD laboratories for the quality of their technology base work. At the same time, DOD is proceeding toward an objective of restoring the ratio of in-house to contract R&D to the lower and better balanced ratios which existed in the early 1960's. Consolidations are also said to be proceeding, where reasonable, to reduce the overall size of the DOD in-house R&D establishment.

(4) *DOD–University Relations.* Currie makes a special point of stressing the need to rebuild the strong and mutually supportive relationships between DOD and the university community that existed after World War II. He says DOD is encouraging greater support of university research and the participation of young university faculty and students in DOD laboratory activities.

3. R&D in the Energy Research and Development Administration (ERDA)

President Ford's budget included a proposal for a new Department of Energy and requested a 21 percent increase in budget authority for R&D in ERDA and a 26 percent increase in outlays for total direct energy R&D throughout all government agencies. As anticipated from his campaign, President Carter has also proposed a Department of Energy, although of a somewhat different makeup than in Ford's proposal, and his budget amendments made some significant changes in Ford's budget. The net effect of Carter's proposals was to reduce budget authority for ERDA R&D by about $100 million below Ford's request. This combination of events, together with the renewed awareness of the nation's energy problems brought about by the cold winter of 1977 and President Carter's promised new energy policy, will keep attention focused on ERDA's budget as it proceeds through the authorization and appropriation processes.

As we have seen, Congressional action on ERDA's FY 1977 budget added some large increases to the administration's request, particularly in solar energy and conservation R&D, with a modest increase in fusion power R&D, as shown by the FY 1977 columns in Table 17. There was also the procedural anomaly that, because of some political in-fighting in the Senate, ERDA's FY 1977 appropriations were passed without passage of the authorization bill. Since the appropriations bills included the proviso that funds could not be expended without enactment of authorizing legislation, a continuing resolution was passed to allow ERDA to operate under its existing authorities through March 31, 1977. The final twist was that rather than pass an ERDA authorization, the new Congress decided quietly to repeal the authorization requirement.

Congressional action on the FY 1978 budget is expected to be at least as lively as that in FY 1977. To start with, Congress has before it two budgets that differ significantly in the controversial nuclear area as well as in some non-nuclear programs. Neither budget proposes even a cost-of-living increase for solar energy, a program that apparently is of great interest to Congress. Further, additional proposals are expected from Carter on the liquid metal fast breeder reactor (LMFBR) and fuel cycle R&D following reviews of these programs that are now underway. Finally, there will be a new cast of characters considering ERDA authorization bills this year. With the disbanding of the Joint Committee on Atomic Energy, most of ERDA R&D will be considered by the House Committee on Science and Technology and the new Senate Committee on Energy and Natural Resources. Also, Thomas O'Neill, the Speaker of the House, is establishing a House Select Committee on Energy. Hanging over all the Congressional deliberations on ERDA will be the proposal for a Department of Energy and the release by Carter in late April of a comprehensive energy policy for the nation.

We will now look at the two FY 1978 ERDA budgets in greater detail – Ford's budget and Carter's revisions. The comparative budget figures are shown in Table 17. To the extent possible, we will outline both the Ford and the Carter positions in each area, although in many cases, less information is currently available on the Carter administration's views than in the supporting documents to the Ford budget, such as *Special Analyses* and *Issues '78*.

The major emphasis of Ford's ERDA budget is on technologies for more effective use of our country's major coal and uranium resources. This emphasis reflects a feeling that federal energy R&D should concentrate on technologies that will be cost-effective and have the potential for making major contributions toward meeting our needs. Characteristics

Table 17. R&D in the Energy Research and Development Administration[1] (Budget Authority in millions; includes plant and capital equipment)

	FY 1977 Budget Request	FY 1977 Approp.	FY 1978 Ford Request	FY 1978 Carter Request
1. Energy Research, Development and Demonstration	$ 2,864	$ 3,002	$ 3,718	$ 3,611
2. Basic Research and Technology Development	265	373	430	430
3. National Security R[D]T&E	819	812	933	933
TOTAL, ERDA R&D above	$ 3,948	$ 4,187	$ 5,081	$ 4,974
1. Energy R,D,&D:				
Conservation R&D[2]	($ 120.0)	($ 153.4)	($ 160.0)	($ 310.3)
Electrical energy and storage systems	46.8	60.0	57.9	90.4
End-use conservation technology	73.2	93.4	102.1	219.9
Fossil energy development[3]	(477.2)	(485.2)	(598.3)	(639.9)
Coal	408.9	409.0	503.7	526.7
Petroleum and natural gas	37.2	43.2	53.1	71.7
In-situ technology	31.1	31.0	41.5	41.5
Solar energy development	(160.0)	(290.4)	(305.0)	(305.0)
Direct thermal	49.2	94.3	55.2	100.2
Solar electric	102.5	174.9	223.8	175.8
Other	8..3	21.2	26.0	29.0
Geothermal energy development	(100.1)	(84.7)	(118.0)	(118.0)
Engineering, R&D, etc.	50.1	54.7	88.0	88.0
Geothermal loan guarantee program	50.0	30.0	30.0	30.0

Table 17 *(continued)*

	FY 1977 Budget Request	FY 1977 Approp.	FY 1978 Ford Request	FY 1978 Carter Request
Fusion power R&D	(392.1)	(415.9)	(512.9)	(432.9)
Magnetic fusion	291.1	304.3	370.9	310.9
Laser fusion	101.1	111.6	142.0	122.0
Fission power reaction development	(789.7)	(777.2)	(942.4)	(743.6)
Liquid metal fast breeder reactor	655.5	685.8	854.8	656.0
Water cooled reactor	48.9	48.9	41.6	41.6
Gas cooled reactor	30.0	30.0	33.0	33.0
All other	55.3	–	–	–
Light water reactor technology	–	12.5	13.0	13.0
Reactor safety facilities	33.3	28.3	27.8	27.8
Nuclear fuel cycle and safeguards R&D	346.7	406.2[4]	636.3	611.3
Environmental control technology	16.1	–	–	–
Environmental research	202.0	–	–	–
Environmental R&D	–	180.9	209.8	215.0
Basic energy sciences[5]	(226.5)	(155.7)	(174.8)	(174.8)
Nuclear sciences[5]	93.2	28.4	26.7	26.7
Material sciences	77.7	74.8	77.5	77.5
Molecular, mathematical and geosciences, etc.	55.6	52.5	67.4	67.4
Advanced energy projects	–	–	3.2	3.2
Technology development and special projects	–	–	12.9	16.1
Nuclear energy assessments	–	–	13.74	16.3
TOTAL, Energy R,D&D	$ 2,864	$ 3,002	$ 3,718	$ 3,611
2. Basic Research and Technology Development:				
High energy physics	$ 220.3	$ 223.8	$ 269.3	$ 269.3
Nuclear physics	–	80.8	85.8	85.8
Space nuclear systems	34.2	–	–	–
Space applications	–	22.6	35.1	35.1
Operational safety	8.7	–	–	–
Nuclear explosives applications	1.3	1.3	1.0	1.0
Life sciences and biomedical applications	–	44.4	39.1	39.1
TOTAL, Basic Research & Technology Development	$ 265	$ 373	$ 430	$ 430

of coal and uranium satisfying these two criteria are (i) they are cheap and abundant; (ii) the technology for producing energy from these resources is relatively inexpensive and can be made reliable, safe, and environmentally acceptable; (iii) the technologies are familiar to utilities; (iv) coal can be converted to liquid and gaseous forms that can replace natural gas and petroleum; (v) nuclear power has economic and environmental advantages over coal in many areas. The conclusion is that coal and nuclear energy are complementary and both need to be developed. Ford views federal support of R&D in energy conservation and solar energy as long-term programs, and undue current emphasis on early demonstration technologies in these areas is regarded as inappropriate because many would not be competitive for widespread application, nor would they have the potential for major contribution in the near-term. His budget papers note that the primary barrier to the widespread use of some of these technologies may be economic and institutional rather than technical.

Although a comparable discussion of the rationale behind Carter's proposals for ERDA was not presented, the main thoughts of his position can be gleaned from his statements in the press, an examination of the budget detail, and the comparison illustrated in Table 18. Under Carter's budget amendments, energy R&D is reoriented to place more emphasis on technologies with near-term impact—conservation, coal,

Table 17 *(continued)*

	FY 1977 Budget Request	FY 1977 Approp.	FY 1978 Ford Request	FY 1978 Carter Request
3. National Security				
RDT&E:				
Weapons R&D and testing	$ 618.8	$ 612.2	$ 690.1	$ 690.1
Naval reactor development	200.1	200.1	242.7	242.7
TOTAL, National Security RDT&E	819	812	933	933
TOTAL, ERDA R&D above	$ 3,948	$ 4,187	$ 5,081	$ 4,974

Source: Agency budget justifications, Ford Budget and Revised.

[1] The breakdown of the ERDA budget into separate programs changed somewhat between FY 1977 and FY 1978. A blank after a program means that it did not appear by that name in the given year.

[2] Does not include funds for the Energy Extension Service. Ford deferred the funds for FY 1977, $7.5 million in budget authority, and requested no funds for FY 1978. Carter requests $8.0 million in budget authority for FY 1978.

[3] In addition, Ford requests $295.0 million in budget authority for the Synthetic Fuels Commercial Demonstration Projects. Carter requests $300 million.

[4] Includes pending supplementals.

[5] The decrease from budget request to appropriation is not "real," but reflects the fact that Nuclear physics is a separate category in the FY 1978 budget and is not included in Nuclear sciences. Nuclear physics is included under Basic Research and Technology Development.

Table 18. Nuclear and Non-nuclear R&D in ERDA (Budget Authority in millions; includes plant and capital equipment)

	FY 1977	FY 1978 Ford	FY 1978 Carter
Direct nuclear energy R&D			
Fission power reactor	$ 777.2	$ 942.4	$ 743.6
Fusion	415.9	512.9	432.9
Reactor safety facilities	28.3	27.8	27.8
Nuclear fuel cycle and safeguards R&D	406.2	636.3	611.3
Subtotal	$1,627.6	$2,119.4	$1,815.6
Direct non-nuclear energy R&D			
Conservation	$ 153.4	$ 160.9	$ 310.3
Fossil	483.2	598.3	639.9
Solar	290.4	305.0	305.0
Geothermal	84.7	118.0	118.0
Subtotal	$1,011.7	$1,181.3	$1,373.2
TOTAL, Direct energy R&D	$2,639.3	$3,300.7	$3,188.8

Source: Agency budget justifications, Ford Budget and Revised.

and solar[1], and less emphasis on long-term strategies – nuclear fission and fusion. From Table 18, we see that the budget for direct energy R&D for the current year is about 62 percent nuclear and 38 percent non-nuclear. Ford would have increased the proportion for nuclear in FY 1978 to 64 percent. Carter, on the other hand, decreased the fraction for nuclear below the FY 1977 level to 57 percent. Beyond the direct energy R&D programs included in Table 18, the only changes made by Carter in the Ford budget were modifications in Environmental R&D, the Energy Extension Service, and Synthetic Fuels Demonstration Projects. Carter proposed no changes in the FY 1977 budget.

Most of basic science R&D fares quite well in the ERDA budget. Environmental R&D increases by 16 percent (18.8 percent in Carter's budget). The Basic Energy Sciences category increases by 12.3 percent. ERDA continues to state that it is reordering priorities in this area to place greater emphasis on research related to non-nuclear technologies; new projects will be started in areas basic to fossil, geothermal and solar energy, and to energy conservation. The small decrease in Nuclear Science is in the plant and capital equipment budget; operating expenses get a small increase of $600,000. Funds are provided for new facilities and modifications to existing facilities, including the national synchrotron light source at Brookhaven (NSF also has initiatives in synchrotron

[1] Although Table 18 shows that Carter proposed no change in the total for Solar, the budget detail shows that he has increased the amount for solar heating and cooling while decreasing the amount for solar electric. The specifics of these changes are discussed later in this section.

Table 19. Budget Statistics for Selected ERDA R&D Programs (Budget Authority, Obligations and Outlays in millions; excludes plant and capital equipment)

	FY 1976			FY 1977			FY 1978		
	BA	Oblig.	Outlays	BA	Oblig.	Outlays	BA	Oblig.	Outlays
Conservation									
77 Budget	$ 72	$ 75	$ 55	$113	$113	$ 88			
78 Budget	73	66	44	145	155	121	$154	$154	$136
Fossil									
77 Budget	$377	$492	$327	$422	$422	$413			
78 Budget	393	323	238	423	547	423	$514	$514	$463
Solar									
77 Budget	$109	$111	$ 81	$142	$142	$111			
78 Budget	109	93	61	258	261	168	$229	$229	$199
Geothermal									
77 Budget	$ 31	$ 33	$ 31	$ 49	$ 49	$ 44			
78 Budget	31	31	30	53	53	48	$ 86	$ 86	$ 66

Source: "Special Analysis P," FY 1977 and FY 1978 Budgets and agency budget justifications, Ford Budget.

radiation); the combustion research facility at Sandia Laboratories, Livermore, California; and the Oak Ridge National Laboratory steam plant. The Basic Research and Technology Development category increases by 15.3 percent. Included in this increase are a 20.3 percent increase in High Energy Physics and a 6.2 percent increase in Nuclear Physics. These increases go toward increased utilization of existing facilities and for funding of the new Holifield Heavy Ion Research Facility under construction at Oak Ridge (the design of a heavy ion accelerator is also being planned by NSF) and of the positron-electron colliding beam project at the Stanford Linear Accelerator. The decrease in the Life Sciences Research and Biomedical Applications category reflects primarily the termination of the ERDA-supported artificial heart system program.

In addition to direct support of R&D, ERDA also supports financial incentive activities to encourage industry to become involved in exploratory and demonstration projects with uncertain payoffs and financial risks. Synthetic Fuels Demonstration Projects are proposed again after being turned down by Congress for FY 1977. This program is intended to enable synthetic fuels plants to develop economic, environmental, regulatory, socio-economic and market information for the future development of synthetic fuels production capability by private industry. The Geothermal Loan Guarantee Program continues at the same level as in FY 1977 and is intended to assist the entry of the private sector into the embryonic geothermal industry. Also in the geothermal area, the Ford budget includes a proposed tax code revision to allow some expenditures for discovery of geothermal energy to be treated as current expenses rather than as capital investment.

Before discussing some of the specific items in ERDA's programs, we should note some features of the budget statistics for ERDA that could be misleading. Table 19 shows the Ford FY 1977 and FY 1978 budget figures for budget authority, obligations, and outlays for selected ERDA programs where the anomalies in the statistics are most striking. Carter's figures will be noted in the discussion when pertinent.

Let us look first at the obligation figures for the fossil program. Actual data in the FY 1978 budget show that FY 1976 obligations were much less than were estimated in the FY 1977 budget. Conversely, obligations for FY 1977 are estimated much higher in the FY 1978 budget than those in the FY 1977 budget. Since budget authority in FY 1977 is about the same in both budgets, it is clear that the sizeable shortfall in obligations in FY 1976 is scheduled to be obligated in FY 1977. As a result, there is an apparent decrease from FY 1977 to FY 1978. A similar situation occurred a year ago in the FY 1977 budget. What this means is that when obligations are delayed in a program, future trends are distorted until the rate of obligations catches up to the rate at which budget authority is provided, and decisions on budgets have to take into account how fast the money can actually be obligated and put to work. In looking only at the trend in obligations for the fossil program one

probably learns more about fiscal mechanics than about actual trends in the program.

Conservation and solar R&D also show a large increase in the current estimates for FY 1977 obligations over the estimates in the FY 1977 budget. In these programs, however, the increases in FY 1977 reflect increases in budget authority provided by Congress. For FY 1978, the Ford budget maintains level budget authority/obligations for conservation and proposes a decrease in solar programs.

It is understood that these recommendations were based, at least in part, on the feeling that the R&D system and/or the stage of development in these areas are already over-taxed by the large Congressional increases, rather than on a decision to decrease the emphasis on conservation and solar R&D. The large shortfall in FY 1976 obligations in fossil may indicate that the appropriations to this program also have exceeded the capacity to support worthwhile projects. From a broad perspective, however, the overall trend in all these programs is one of expansion, as shown by the steady increase in outlays and by the fact that obligations continue to exceed outlays.

Carter's ERDA budget in these areas is basically consistent with his statements during the campaign. He almost doubles the budget authority for conservation, proposes a modest increase over Ford's budget in fossil, and maintains Ford's request for solar but with a significant reallocation. Even if these increases are sustained by the Congress, it will be at least a year before we will know whether the system is capable of utilizing these additional funds effectively.

Now let us review briefly some of the specific proposals in the Ford and Carter budgets for ERDA:

(1) *Conservation*. Ford emphasizes long-term R&D. Near-term improvements are stressed through the private sector and market forces, with the government role being to provide incentives through regulation. Transportation energy conservation and improved conservation efficiency are two areas that receive increased emphasis. Carter, on the other hand, increases the emphasis on near-term R&D under the assumption that government and industry have shared responsibility in this area. Conservation in buildings, industry, and transportation are stressed. Funds are provided to support the Electric-Hybrid Vehicle Research, Development and Demonstration Act.

(2) *Fossil*. Ford requests increases for coal liquefaction and gasification, particularly gasification of low BTU coal. A large part of the increases is for scale-up activities during development leading to commercialization. Enhanced oil recovery and oil shale are also increased. Carter increases the Ford request by $41.6 million to further emphasize near- and mid-term fossil energy supply. Low BTU coal gasification, direct combustion, demonstration plants, and enhanced gas and oil recovery all receive increases in the Carter budget.

(3) *Solar*. In FY 1977 Congress increased Ford's request for Solar Heating and Cooling. His FY 1978 request for this program is back to

the level proposed for FY 1977. Increased emphasis is placed on solar cooling with a decrease in emphasis on solar heating. No new demonstration plants are proposed in this area; the existing demonstrations will be completed and studied. The big increase in solar electric is principally for the construction of a 10 MWe central receiver pilot plant. While Carter requests the same total for solar, he changes the emphasis. The time-line for construction of the central receiver pilot plant is extended by 1 year with the savings applied to increasing the operating expenses for solar electric and increasing the emphasis on solar heating and cooling through large increases in commercial and residential demonstration programs.

(4) *Geothermal.* This program includes a 50 MW geothermal demonstration power plant, the first U.S. commercial scale demonstration project for hydrothermal resources. Carter made no changes here.

(5) *Fusion.* Much of the activity in this area is directed at enhancing the scientific understanding of fusion phenomena—better understanding of plasma behavior to allow containment of plasmas and better understanding of laser-matter interactions. Practical generation of power from fusion is estimated to be billions of dollars and many years away. *Issues '78* states that ERDA is currently analyzing the program to determine the proper future pacing of this long-term research effort. Carter decreases the fusion budget, principally through cutting back on construction for the mirror fusion test facility, the Tokamak reactor, the intense neutron source facility, the high energy laser facilities, and the electron beam fusion facilities.

(6) *Liquid Metal Fast Breeder Reactor (LMFBR).* Ford requests a 25 percent increase in budget authority in order to initiate the new facility projects required to answer both safety and environmental questions and component reliability fuel cycle performance questions for a commercial LMFBR energy system. Funds are requested for continuation of the Clinch River Breeder Reactor demonstration project and for completing plans for the next large plant project in the LMFBR demonstration program. A determination of the acceptability of widescale commercial development of LMFBRs is scheduled for 1986. Carter's proposals give a much more modest and restrained flavor to the LMFBR program. His budget reduces Ford's request by $198.8 million to below the level appropriated for FY 1977. The Clinch River Breeder Reactor is reduced by $84.8 million below Ford's request. In addition, the Carter administration has launched an intensive review of the LMFBR program, including the Clinch River Breeder Reactor, to reassess the role of LMFBRs in the nation's energy future. The program objectives and planned activities may change as a result of this review.

(7) *Nuclear Fuel Cycle R&D.* This program increases from $182.7 million to $379.8 million in Ford's budget. All three subprograms, Uranium Resource Assessment, Nuclear Fuel Cycle, and Waste Management, receive sizeable increases. While Carter's budget includes the same totals for FY 1977 and FY 1978, he refrains from allocating the total

Table 20. National Aeronautics and Space Administration Budget Summary (in thousands)

	Budget Plan			
	FY 1976	Transition Quarter	FY 1977	FY 1978*
Research and Development				
Space Flight	$1,560,574	$406,500	$1,668,700	$1,753,500
Space shuttle	1,206,000	321,000	1,318,100	1,349,200
Space flight operations	188,674	48,400	199,200	267,800
Expendable launch vehicles	165,900	37,100	151,400	136,500
Space Science	$ 434,126	$116,400	$ 380,325	$ 415,700
Physics and astronomy	159,300	43,500	166,300	224,200
Lunar and planetary exploration	254,250	67,464	191,900	158,200*
Life sciences	20,576	5,436	22,125	33,300
Applications	$ 178,230	$ 47,700	$ 198,200	$ 233,800*
Aeronautics and Space Technology	$ 250,250	$ 63,100	$ 272,100	$ 328,700
Aeronautical research and technology	175,350	43,800	190,100	231,000
Space research and technology	74,900	19,300	82,000	97,700
Energy Technology Applications	$ 5,900	$ 1,500	$ 6,000	$ 4,500
Tracking and Data Acquisition	$ 240,800	$ 63,400	$ 255,000	$ 281,700
Technology Utilization	$ 7,500	$ 2,000	$ 8,100	$ 8,100
TOTAL RESEARCH AND DEVELOPMENT	$2,677,380	$700,600	$2,788,425	$3,026,000
Construction of Facilities	$ 82,130	$ 10,750	118,090	$ 161,800
Research and Program Management	$ 792,312	$220,169	$ 844,777	$ 846,989
TOTAL	$3,551,822	$931,519	$3,751,292	$4,034,789
OUTLAYS	$3,669,022	$951,428	$3,705,750	$3,914,789

Source: Agency budget justification.
* Reflects Carter amendments.

among the subprogram areas. His budget states that the program is currently under review by his administration, and that the distribution of funds among the subprograms and any adjustments to the total funding will be submitted to Congress after the review is completed. A major concern in the review is the appropriate balance for support of fuel reprocessing and of alternatives to reprocessing, such as spent fuel storage. The Ford budget emphasizes reprocessing with a much lower level of funding requested for evaluation of alternatives. In a review of the Ford budget by the Carter administration, State Department and Arms Control and Disarmament Agency officials proposed a budget that placed higher priority on alternatives to reprocessing. Constrained by the time requirements for submitting his budget amendments, Carter decided to leave the total for Fuel Cycle R&D at the level proposed by Ford until a more thorough review of these programs could be completed.

4. R&D in the National Aeronautics and Space Administration (NASA)

All of the NASA budget is classified by OMB and NSF as R&D except for about $23 million for scientific and technical information activities which historically have usually been excluded from R&D statistics. Table 20 shows the entire NASA budget by the programs that are authorized separately by Congress. The FY 1978 figures reflect the amendments recommended by President Carter—an increase of $10 million in the lunar and planetary program to $15 million for FY 1978 studies of possible future missions to Mars to follow up the discoveries of the Viking spacecraft, and an increase of $5 million to start back-up Landsat D spacecraft to hedge against the possibility of a failure when that advanced earth resources survey satellite is launched in 1981.

In total, the NASA budget shows an increase of about 7.5 percent in budget authority. A misleading increase of only about 2 percent is reflected in "Special Analysis P" on the basis of the obligations estimates in the budget which distort the budget trend by assuming no carry-over of unobligated R&D funds into FY 1978, thereby inflating artificially the FY 1977 obligations level by perhaps $200 million. FY 1977 obligations may, however, prove to be higher than expected for another reason. A jobs bill initiated in Congress as an additional economic stimulus measure includes a $95 million appropriation to NASA to provide additional employment by accelerating development and production work in the space shuttle program.

In general, the NASA program in the FY 1978 budget follows the lines anticipated in NASA's long-range planning in recent years, with few surprises. The principal projects include the following:

(1) *Space Shuttle.* Development continues and production will be initiated for three additional space shuttle orbiters to provide, with the two development orbiters now being built, a total national fleet of five.

(2) *Space Telescope.* This 2.4 meter instrument, long a major goal of

Table 21. National Institutes of Health[1] (Budget Authority in millions)

	FY 1975	FY 1976	FY 1977		FY 1978[2]
	Actual	Actual	President's Budget	Congressional Appropriation	Budget
Cancer	$ 670.1	$ 744.5	$ 669.5	$ 794.9	$ 800.8
Heart, Lung, & Blood	303.6	349.4	330.5	374.7	383.7
Dental	44.4	45.9	49.1	51.4	55.0
Arthritis, Metabolism, & Digestive Diseases	161.2	175.5	175.0	199.4	205.2
Neurological, etc.	129.3	136.8	141.8	148.4	154.9
Allergy & Infectious Diseases	110.7	119.2	130.5	132.9	147.0
General Medical Sciences	135.5	146.5	152.6	161.1	180.3
Child Health & Human Development	116.6	127.1	123.0	135.8	146.6[2]
Aging	14.3	17.6	24.6	27.8	32.5
Eye	39.5	45.6	43.1	59.4	60.8
Environmental Health Sciences	32.0	36.0	44.0	46.9	56.6
Research Resources	127.9	130.0	92.0	137.0	101.6
Foggarty International Center	5.4	5.7	7.5	8.0	8.4
National Library of Medicine	29.0	29.2	35.2	35.2	36.7
Office of Director	14.9	15.3	16.2	16.2	17.9
TOTAL	$1,934.3	$2,124.4	$2,034.5	$2,329.2	$2,387.8

Source: Agency budget justification.
[1] Excludes training and "buildings and facilities."
[2] Reflects Carter amendments

the astronomical community, will proceed into actual development under a schedule calling for it to be placed in orbit by the space shuttle in 1983.

(3) *Jupiter Orbiter-Probe*. This mission to be launched in 1981 is to reach Jupiter in 1984 to explore the planet, its atmosphere, and its moons; initiation of the project in FY 1978 maintains continuity in the planetary exploration program.

(4) *Landsat D*. This is to be an advanced earth resources satellite to carry a seven-channel thematic mapper to experiment with more discriminating techniques of detection and measurement of crops and other natural resources.

(5) *Search and Rescue*. One slight surprise in the NASA budget is a new project to place special transponders on previously planned weather satellites to permit the prompt location of downed aircraft or ships in distress.

The Ford Budget Document and the accompanying *Issues '78* make a special point in the case of NASA, for some reason, of mentioning what is *not* included in the FY 1978 budget. Reductions and deferrals "to achieve the objective of constraining the total federal budget" are said to include deferral of a Lunar Polar Orbiter mission; reduced general support for NASA's R&D activities in aeronautics and space (a contrast to the emphasis on "real growth" in the NSF and DOD budgets!); and deferral for later consideration of proposed engineering and design studies of a possible future manned earth-orbiting space station. On this last item, *Issues '78* goes out of its way to present at some length OMB's concerns and arguments against the idea of a manned space station. This looks like an example of an advance attack by the budgeteers against a R&D proposal to study in depth an idea that might or might not someday be proposed as a project. It is an interesting contrast to the philosophy in DOD R&D, where in-depth studies of future options are encouraged and control is exercised by limiting carefully the systems approved for full-scale development.

5. *R&D in the Department of Health, Education and Welfare (HEW)*

This section includes a discussion of the R&D in the National Institutes of Health (NIH) and Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA). Research and development in a number of other parts of HEW are summarized in Table 8, a crosscut of the social science R&D supported by the federal government.

a. R&D in the National Institutes of Health (NIH)

Looking first at what happened to the President's FY 1977 budget request for NIH, we see from the FY 1977 column in Table 21 that the traditional tug-of-war in this area between the Administration and Congress continued (see AAAS–77, p. 74*ff*.). The two most popular insti-

tutes with strong lobby groups, Cancer and Heart, Lung and Blood, and the Research Resources programs received sizeable increases in the Congressional appropriations process. A major point of contention in Research Resources is the Biomedical Research Support Grants Program that provides institutional support on a formula basis to allow institutions to strengthen and broaden their biomedical research programs. Institutions that have received grants through the competitive process are eligible for institutional awards, with the amount of the award determined by the amount of funds received in competitive grants. For years, the administration has recommended that this program be terminated, and Congress always has restored it. Caught in the middle are NIH administrators. They continue to plan for the next year's program (history is on their side) while higher levels in the Executive Branch are recommending its termination. This situation seems destined to continue in the FY 1978 budgetary process as the administration (both Ford and Carter) again has recommended a zero budget for Biomedical Support Grants. A similar tug of war exists on NIH training programs, as will be described briefly later.

For FY 1978 President Ford requested an increase of $53.6 million (2.3 percent) for R&D in NIH. President Carter's only change was to add $5 million. While this budget request provides no "real" increase after allowing for inflation, it is a stronger proposal than was submitted for FY 1976 and FY 1977, when decreases were reflected in the NIH budget (see AAAS-77, pp. 74-77). Table 21 shows that just as in the FY 1977 budget, the Allergy and Infectious Diseases and General Medical Sciences programs are slated to receive the largest dollar increases. These two institutes support much basic research in colleges and universities, and thereby, these proposed increases are in tune with President Ford's emphasis on providing real increases for basic research. Under the Carter amendments, the Child Health and Human Development program receives the third largest dollar increase, reflecting his addition of $5 million for studies of reproductive physiology and prenatal development. Cancer and Heart, Lung, and Blood, the two largest institutes and the ones so popular with Congress, receive only relatively small increases. The divergence between Congress and the Executive continues as indicated by the Congressional action to date.

Most of R&D in NIH is under indefinite authority and therefore requires no authorization action preceding passage of the appropriation bills. Early action in the few areas requiring authorization, however, provides a sense of what to expect from Congress this year. For Heart, Lung and Blood, Cancer, Population (in Child Health and Human Development), and the Library of Medicine, initial mark-up in the House provided a 15 percent increase over the 1977 appropriations; a larger increase is expected in the Senate mark-up. At the cut-off time for this report, there had been no mark-up of the appropriations bills.

In addition to the increase in the Institute of Child Health and Human Development, President Carter's amendments include changes

Table 22. Selected Support Categories of NIH Budget (Budget Authority in thousands)[a]

	FY 1977	FY 1978	FY 1978 Carter Revisions
Regular Grants	999,618	1,052,691	1,057,691
Noncompeting	(733,984)	(768,795)	(768,795)
Competing	(265,634)	(283,896)	(288,896)
Research and Development Contracts	388,488	391,838	391,838
Intramural Research[b]	249,071	268,435	268,474

[a] Source: Agency budget justification.
[b] The Carter amendments propose small changes among Intramural Research, Direct Operations, Program Management, and Disease Control, but the total for these four categories is the same as that proposed in the Ford Budget.

in the NIH budget that involve no increases or decreases in funds. He withdrew the previous administration's request to consolidate all funding for NIH into three appropriations: one for all grant and contract programs of NIH Bureaus, Institutes, and Divisions; one for buildings and facilities; and one for all expenses of intramural research in all the institutes and of NIH administration, which would be consolidated into an appropriation to the Assistant Secretary for Health together with intramural and administration activities of other HEW health programs. The Carter amendments restored all NIH funding to the traditional accounts of the individual institutes. President Carter also sent some words of encouragement to NIH. In remarks made at the announcement that Dr. Donald S. Fredrickson would stay on as Director of NIH, HEW Secretary Califano called basic research "critical to our society," and said, "It needs added resources and I'll try to get them for you." With only a tiny increase in FY 1978, we will have to wait for the FY 1979 budget to see what meaning these statements take on.

To support its research program NIH uses three principal mechanisms: research grants, R&D contracts, and intramural research. Table 22 shows the funds allocated to each of these. Regular grants to universities, clinics, and medical centers increase by $53.1 million (5.3 percent). ($58.1 million, 5.8 percent in Carter's amendments.) The discussion of health research in the Ford budget states that this overall increase includes a 7 percent increase in basic research; the Carter amendment would presumably add a negligible further increase. With the standard allowance for inflation it appears that NIH grants would be supported at about the same level as in FY 1977.

National Institutes of Health grant awards are usually made for three years. This means that each year a portion of grant funds must go to fulfill prior-year commitments. In FY 1978, $769 million, about 73 percent of total grant funds, would go to the support of these continua-

tions, referred to as noncompeting grants in Table 22. The funds for competing grants include awards for both new grants and grant renewals for an additional 3-year period. The impoundment and deferral of NIH funds in the early 70's have had a significant impact on the balance between competing and noncompeting grants supported in recent years. Using FY 1973 impounded funds released late in FY 1974, many competing awards were made in FY 1974 for periods that extended beyond FY 1975, thus requiring no continuation in FY 1975. This freed more funds in FY 1975 for competing applications. Together, these two phenomena increased the requirement for continuation support in FY 1976. Noncompeting continuations consumed 69.5 percent of the funds for research grants in FY 1976, an increase of 8.8 percent over FY 1975. Correspondingly, the proportion of funds in FY 1976 for competing new and renewal grants was the lowest since 1970. According to estimates in the current budget, this trend appears to be continuing in FY 1977 and FY 1978, although the balance is changing slightly in favor of competing grants in FY 1978.

The other major method of supporting extramural research is through R&D contracts. Contract research is slated to increase by only 0.86 percent in FY 1978. Between FY 1967 and FY 1976, however, support of R&D contracts grew tremendously. In FY 1967, 12 percent of the research budget supported contracts while the proportion was 24 percent in FY 1976, although there was a decline of 2 percent from FY 1975 to FY 1976. This trend is partially in response to legislation that has recommended focused research efforts aimed at obtaining information directly related to the solution of specific problems. A case in point is the National Cancer Act. The Cancer Institute uses the contract mechanism more than any other institute. In FY 1968, Cancer used 45 percent of the total NIH contract funds; in FY 1976 the fraction grew to 64 percent. More recently, the Cancer Institute has been decreasing funds for contracts and increasing those for grants, which is consistent with the wishes of those who feel that a cure for cancer can be neither legislated nor bought, but will come from knowledge accumulated from a broad-based research program that allows scientists to pursue their own ideas.

Contrary to what might be expected, profit-making organizations have not reaped the benefits of the increase in contract research. In FY 1968, institutions of higher education (IHE'S) received 32.7 percent of the contract funds and profit-making organizations received 43.0 percent. In FY 1976, the fractions were 39.3 percent and 33.7 percent, respectively, which represent a narrowing of a difference that favored IHE's even more around FY 1973. This trend has stimulated the profit-making organizations to request greater eligibility for grant awards.

Areas of special emphasis in the FY 1978 NIH budget are the following:

(1) The disciplines of genetics, immunology, virology, and cell biology. NIH feels that these four areas of basic science are

moving forward most rapidly, are considered to be most promising, and are attracting the attention of the finest minds in research. Although these disciplines are represented in all the institutes, they are especially prominent in General Medical Sciences and Allergy and Infectious Diseases, the two institutes scheduled to receive large increases.

(2) A cooperative effort between the Cancer Institute and EPA in environmental carcinogenesis as per the Toxic Substances Control Act. Cancer would receive $4 million for this.

(3) Expansion of efforts in Allergy and Infectious Diseases toward the development of safer technology for use in DNA recombinant and other genetic recombinant research.

(4) Continued growth of the National Institute on Aging.

(5) Research on the effects of chemical, physical, and biological environmental agents on human health in the Environmental Health Sciences Institute.

(6) Added by President Carter: Studies of the reproductive process, prenatal and infant nutrition, birth defects, and adolescent pregnancy in Child Health and Human Development.

Let us now look at some specific features of the NIH budget.

(1) *National Cancer Institute.* Although the net increase is only $4 million, the increase in research programs is almost $15 million, including a $9 million increase in physical and chemical carcinogenesis and a $5 million increase in clinical treatment research. These increases are partially offset by a $13.5 million decrease in resource development, $10 million of which is a decrease in construction.

(2) *Arthritis, Metabolism, and Digestive Disease.* In response to the Congressional report on the FY 1977 budget, special centers were established for arthritis and kidney research. These centers together with those for diabetes research provide maximum visibility to research on these common diseases.

(3) *Allergy and Infectious Diseases.* The two disease programs increase significantly: Immunology, Allergic and Immunologic Diseases increase by almost $4 million (10.6 percent) and Microbiology and Infectious Diseases increase by almost $6 million (8.8 percent). To support research in these areas more research grants will be awarded. An increase of $8 million will go to the support of 86 more competing grants. Included in these totals is support of 46 more new grants.

(4) *General Medical Sciences.* Cellular and Molecular Basis of Disease is increased by $6.6 million (9.6 percent) and Genetics is increased by $7.6 million (12.4 percent). About 120 more research grants will be awarded in Cellular, and about 100 more in Genetics. Overall there is a $19 million increase for funding of research grants—an increase of $24 million in competing and a decrease of $5 million in noncompeting. About 200 more new grants will be awarded in FY 1978.

(5) *National Institute on Aging.* In January 1977, the first endowed

Table 23. NIH Training Programs (Budget Authority in thousands)

	FY 1977		FY 1978
	Ford	Carter	Ford & Carter
Individual	$ 29,158	$ 29,446	$ 31,247
Institutional	104,982	104,694	91,639
TOTAL	$134,140	$134,140	$122,886

Source: Agency budget justification

Table 24. Alcohol, Drug Abuse, and Mental Health Administration (Research only; Budget Authority in millions)

	FY 1975	FY 1976	FY 1977		FY 1978	
			President's Budget	Congress Approp.	Ford	Carter
General Mental Health	$ 93.2	$ 92.9	$ 83.0	$106.9	$ 99.5	$106.9
Drug Abuse	34.1	34.0	34.0	34.0	33.0	34.0
Alcoholism	11.0	11.8	10.0	12.6[1]	13.2	13.2
TOTAL	$138.3	$138.7	$127.0	$153.5	$145.7	$154.1

Source: Agency budget justification.
[1] In the Carter Budget this is $12.8 million resulting from a proposed supplemental for pay raises.

professorship in geriatrics at an American medical school was initiated at Cornell University Medical College. This is a reflection of the almost complete absence of clinical research on aging in the United States today. For FY 1978, the Institute on Aging is requesting funds to award two exploratory grants to determine the feasibility of establishing university-based and medical school-affiliated aging research centers. The program will attempt to develop interest in clinical research on aging in order to bring geriatric medicine into established practice.

(6) *Environmental Health Sciences.* A new university-based Environmental Health Science Center will be added to the seven currently in operation. Three Marine Biomedical Research Centers will be initiated in FY 1978 in response to language in the Congressional report on the FY 1977 budget.

(7) *Training.* Although funds for training are excluded from the R&D statistics in the tables, they are used for the training of researchers, and therefore we will discuss them briefly. In the FY 1978 budget (Ford and Carter budgets are the same in this area) there is an emphasis on postdoctoral individual fellowships as recommended by the National Academy of Sciences in their report, *Personnel Needs and Training for*

Biomedical and Behavioral Research, 1976 Report. The budget includes funds for 1,000 new postdoctoral individual fellowships, but no new funds for predoctoral individual fellowships or institutional National Research Service Awards, except for the Minority Access to Research Careers (MARC) Program in General Medical Sciences. As Table 23 shows, in general there is a decrease in institutional awards in FY 1978. The NIH materials supporting the amended FY 1978 budget reflect a FY 1977 change that would accelerate this shift. If precedents are any indication, however, Congress is likely to increase the support for training over the administration's request. Again the NIH administrators are caught in the middle and frustrated by the lack of an assured support base on which to develop broad-based, long-term plans. For FY 1978, they have to plan for the possibility of continuing the full range of training activities under the National Research Services Awards Act; that is, support of pre- and post-doctorals through institutional and individual awards.

b. R&D in the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA)

A look at Table 24 shows that mental health also continued to be an area of difference between the Ford administration and Congress. Congress increased the administration request for FY 1977, and the Ford administration again requested a decrease for FY 1978. The Carter amendments increase Mental Health and Drug Abuse to be level with the FY 1977 appropriations. Examination of the complete ADAMHA budget as amended by Carter, including training and community programs in addition to research, shows that the general rule in modifying the Ford budget seems to have been to not change those areas that increase or remain level, and to increase to the FY 1977 level those areas that decrease. Thus, a total ADAMHA budget that decreases by more than $50 million in Ford's budget increases by almost $2 million in Carter's amendments.

Some details of the ADAMHA budget are:

(1) *Research*. In all three areas, research in FY 1978 will consist largely of extensions of programs undertaken earlier. Of Carter's $7.4 million increase over the Ford request for Mental Health, however, $6.3 million is allocated to support of competing new and renewal grants.

(2) *Training*. In the area of training, both the Carter and Ford budgets propose the termination of research and training grants and predoctoral fellowships. Carter, however, consistent with the rule stated above, proposes the same level of support for training as was appropriated in FY 1977. Ford, on the other hand, proposes a decrease of $45.6 million.

6. *R&D in the National Science Foundation (NSF)*

With a Presidential budget message that emphasizes "real growth

for basic research and development programs," the substantial increase that is proposed for NSF R&D is no surprise. As illustrated in Table 25, total NSF R&D, including R&D facilities, is scheduled to increase by 11.2 percent, a real growth of over 5 percent using the administration's 6 percent rate of inflation. R&D in the three basic science directorates, which include the programs in Table 25 from Mathematical Sciences through Social Sciences, receive an overall increase of 12.9 percent, while basic research would go from $612 million in FY 1977 to $688 million in FY 1978, a 12.4 percent increase.

President Carter left the NSF budget completely unchanged. It is by

Table 25. National Science Foundation[1] (Budget Plan in millions)

	FY 1975 Actual	FY 1976 Actual	FY 1977		FY 1978 Budget
			Budget Request	Current Plan[2]	
Mathematical Sciences	$ 16.5	$ 17.3	$ 20.9	$ 19.9	$ 21.8
Computer Research	11.8	13.2	15.8	15.5	17.0
Physics	42.2	45.2	55.4	54.1	59.4
Chemistry	32.7	34.7	42.4	40.2	44.3
Engineering	34.3	35.8	44.6	42.9	46.1
Materials Research	43.5	46.1	54.1	51.6	60.6
Astronomical Sciences	44.1	48.6	54.7	52.3	58.0
Atmospheric Sciences	36.3	44.5	51.4	49.6	55.9
Earth Sciences	23.5	27.1	32.2	29.0	34.8
Ocean Sciences	50.7	47.1	56.5	53.2	58.9
Arctic Research	3.6	5.6	5.0	4.7	5.8
Physiology, Cellular & Molecular Biology	41.9	43.7	54.2	51.1	58.9
Behavioral & Neural Sciences	18.5	19.7	24.4	23.6	28.3
Environmental Biology	26.1	26.8	32.6	30.6	33.6
Social Sciences	17.8	18.8	21.5	21.4	24.0
Antarctic Program					
Research	4.5	4.3	5.1	5.6	6.5
Support	21.4	43.3	39.9	39.8	41.0
Science Education R&D	23.0	10.9	11.7	11.2	8.2
Science & Society	1.7	2.3	3.4	4.3	5.2
Research Applied to National Needs	83.6	72.0	64.9	67.6	78.0
Scientific, Technological, & International Affairs	24.9	22.4	22.0	20.6	22.6
Program Development & Management	37.9	42.2	43.5	45.8	47.8
TOTAL	$640.5	$670.6	$756.2	$734.3	$816.7

Source: Agency budget justification.

[1] Excludes Science Manpower and Science Education other than R&D.

[2] Current plan is based on actual legislation and deferrals, carryovers, and adjustments of prior year budgets.

Table 26. FY 1977 Congressional Decreases in the NSF Basic Science Directorates (Budget Plan in millions)

Mathematical & Physical Sciences & Engineering	$10.6
Astronomical, Atmospheric, Earth & Ocean Sciences	10.0
Biological, Behavioral, & Social Sciences	6.2
Total Decreases	$27.8

Source: Agency budget justification.

no means certain, however, that the proposed increases will be sustained by the Congress. The large increase recommended last year in the FY 1977 NSF budget was given a substantial cut as can be seen by comparing the Current Plan with the President's budget request for FY 1977 in Table 25. In the three basic science directorates, the appropriation was $27.8 million (5 percent) less than requested, distributed as shown in Table 26. The 19.7 percent increase requested in these areas for FY 1977 ended up as a still respectable 14.2 percent increase after the appropriation action. The FY 1978 budget for NSF basic science R&D would not hold up so well under a similar decrease. A 5 percent reduction would remove much of the real growth for NSF R&D recommended in the administration budget.

In preliminary actions in Congress on the NSF FY 1978 authorization bill, the basic science directorates have fared well. The Senate Subcommittee on Health and Scientific Research approved the full amount requested by the President; the House NSF Authorization Bill cuts the administration request for basic science R&D by 2.8 percent, still leaving an increase of over 10 percent which allows for real growth of about 4 percent. The Senate subcommittee also provided full funding for RANN, whereas the House authorization included a 6.8 percent decrease, but supported the budgeted increase for earthquake engineering, and earmarked funds for applied social research and policy-related scientific research. Two new features introduced by the Senate subcommittee are a 2-year authorization and a provision allowing industrial researchers to compete for research funds on an equal basis with researchers in the academic sector. This proposal has set off a heated debate within Congress, NSF, and the industrial and academic research communities which is certain to continue as the NSF authorization bill makes its way through Congress. The all-important appropriations actions—the process that actually provides the money—are still in their early stages.

As Table 25 shows, the proposed increase for FY 1978 is spread throughout the NSF R&D programs. A more detailed analysis of the increase is presented in Table 27 which also shows how the increase is divided among the NSF categories of support. About one-quarter of the increase is for research on fundamental laws, processes, and phenomena spread largely among the three basic science directorates.

Table 27. NSF: Crosscut of FY 1978 Increases by Activities and Support Categories (dollars in millions)

	Research								
	Fundamental Laws, Processes and Phenomena	Instrumentation Equipment, Facilities and Research Resources	Environment and Resources	Technology Related Research	Subtotal Research	Science Education	Science Policy Information and Related International Activities	Staff Salaries and Other Operating Costs	Total Increase
Mathematical and Physical Sciences and Engineering	$5.48	$17.28	–	$2.55	$25.31	–	–	–	$25.31
Astronomical, Atmospheric, Earth, and Ocean Sciences	3.60	4.50	$16.50	–	24.60	–	–	–	24.60
U.S. Antarctic Program	–	–	2.15	–	2.15	–	–	–	2.15
Biological, Behavioral and Social Sciences	10.35	6.20	1.60	–	18.15	–	–	–	18.15
Science Education	–	–	–	–	–	1.40	–	–	1.40
Research Applied to National Needs	–	–	10.40	–	10.40	–	–	–	10.40
Scientific, Technological, and International Affairs	–	–	–	–	–	–	2.00	–	2.00
Program Development and Management	–	–	–	–	–	–	–	2.04	2.04
Special Foreign Currency	1.01	–	–	–	1.01	–	–	–	1.01
TOTAL Increase	$20.44	$27.98	$30.65	$2.55	$81.62	$1.40	$2.00	$2.04	87.06
Percent of Total Increase	23.5%	32.2%	35.2%	2.9%	93.8%	1.6%	2.3%	2.3%	100.0%

Source: Agency budget justifications.

Table 28. Relative Balance Among NSF Support Categories

	Percent of Total Budget
Research ($688.1 million basic; $78.1 million applied; $47.2 million R&D facilities)	83.5%
Science Education	8.6%
Science Information, Science Policy, International Science Related Activities	2.5%
Staff Salaries and Other Operating Costs	5.4%

Source: Agency budget justification.

Complementing the increase in fundamental research is a $28 million increase in funds used to upgrade instrumentation, equipment and facilities in the basic sciences. A major item in this area is the provision of enhanced capabilities for utilization of synchrotron radiation through upgrading and expansion of present facilities and development of a new source. A portion of the increase also would go toward increasing the utilization of existing accelerators. Among the other items to receive increases are the computer at the National Center for Atmospheric Research, the Very Large Array asronomy facility, containment facilities for research involving recombinant DNA, and the design studies for a heavy ion accelerator. Maybe less flashy, but certainly equally important, are the increases provided for replacement of obsolete laboratory equipment and acquisition of new sophisticated instruments.

The third category receiving a major increase is research in the general area of the environment and resources. About one-half of this increase will go toward earthquake research, which will double in FY 1978. Emphasis will be placed on earth science research aimed at developing improved techniques for earthquake prediction and on the study of earthquake engineering as a part of the new initiative on earthquake problems, mentioned earlier, in which the U.S. Geological Survey also has a major role. Also receiving major increases are studies of the atmosphere and oceans, related to both weather and climate and to the impact of pollutants, and research on living and mineral resources in the marine environment.

Taken together, the research support categories account for almost 94 percent of the increase in the NSF budget. The relative balance among the four support categories in the NSF program for FY 1978 is shown in Table 28. We see that the relative position of the research category has been strengthened in the FY 1978 NSF budget request. Other interesting features of the NSF budget are the following:

(1) *Colleges and Universities.* In FY 1978 NSF will account for 18 percent of the federal R&D funds to colleges and universities. However, NSF will account for more than 46 percent of federal funds to colleges

and universities for basic research in non-defense and non-space areas. This compares to about 42 percent in FY 1975.

(2) *Food-Related Research.* Complementing the new competitive grants program in basic research at the Department of Agriculture, NSF will support research on plants, biological fixation of nitrogen, photosynthetic efficiency, and nonconventional sources of food. This research is aimed at enhancing the country's ability to produce food while minimizing dependence on chemical fertilizers.

(3) *Physics.* There is an increase of 9.8 percent for physics. The general NSF budget material states that, in part, this increase will allow NSF to assume support of some ERDA dropouts in nuclear physics. The nuclear physics program is slated to increase by only 8.3 percent, however, only slightly more than is necessary to keep pace with inflation and much less than needed to assume the slack from ERDA. Atomic, molecular, and plasma physics receives an increase of 9.5 percent; this program also attempts to pick up dropouts from the mission agencies. If the government is serious about providing support for many of the physicists who once obtained funds from the mission agencies, NSF's budget in this area would need to increase much more than it has in recent years. But perhaps this is not a major concern?

(4) *The Computer Intelligence Systems.* The activity in the computer science program has been increased to partially compensate for the shift from basic to applied research by the Advanced Research Projects Agency of DOD.

(5) *Science Education R&D.* This program includes a Research in Science Education activity that began in FY 1977 in response to a Congressional mandate; the activity goes from $2,500,000 in FY 1977 to $2,600,000 in FY 1978. Development decreases significantly from $8,750,000 to $5,600,000. The decrease is due to three factors: (i) completion of several large development projects; (ii) continuation of a few studies and needs assessments to provide a basis for subsequent development; (iii) increased emphasis on prototype projects prior to fullscale development.

(6) *Research Applied to National Needs (RANN).* Most of the $10.4 million increase is in the Environment activity, which increases by 38.6 percent to $34.5 million as part of the new and expanded efforts on earthquake engineering and on utilization of earthquake engineering research results. Other areas emphasized in the RANN program are: acceleration of research on renewable resources, particularly on biomass utilization and nonconventional sources of food; a thorough evaluation of the State Science, Engineering and Technology experimental program; continuation of emphasis on strengthening research and innovation in small R&D businesses.

(7) *Research and Development Centers.* Although institutional support to R&D centers is not a separate category in the NSF budget, the support provided to some of these centers is clearly identified in the budget detail. The party line is that these institutions by and large do not receive

special consideration when developing the budget, but are judged on the same basis as all other program elements. How do these institutions fare in comparison to the total NSF budget? For special institutions, including the five special astronomy centers, the National Center for Atmospheric Research, the Materials Research Laboratories (taken over from DOD in response to the Mansfield Amendment), and the National Magnet Laboratory, NSF support increases by 10.3 percent in FY 1978, slightly less than the overall NSF increase.

7. *R&D in the Environmental Protection Agency (EPA)*

The total budget for EPA is presented under six appropriations: Abatement and Control; Enforcement; Research and Development; Agency and Regional Management; Buildings and Facilities; and Scientific Activities Overseas (Foreign Currency Program). Our discussion will focus on the Research and Development appropriation, although R&D activities are included in the Foreign Currency Program as part of the cooperative research and demonstration programs in other countries. Also deserving of mention is the Office of Research and Development in EPA. The budget and programs of this office are not completely coincident with those in the research and development appropriation; however, using the symbolism of a Venn diagram, the area of overlap of circles describing the two domains would be about 98 percent. (An indication of the differences between the two is obtained by comparing Table 29 with Table 30.) All of EPA's R&D activities have in common the objective of providing the scientific information and technical tools on which to base standards and effective control strategies in the regulation, prevention, and abatement of environmental pollution.

Table 29 gives a breakdown of the principal R&D activities of EPA by "media" as presented in the EPA Congressional justifications. The entries are in budget authority, but totals for obligations and outlays are also shown at the bottom of the table. For obvious reasons, the $1.8 million increase in budget authority gets more mention in the Budget Documents than the decreases in obligations and outlays. The tone in the EPA R&D budget justifications, however, is clearly one of continuation and completion of ongoing programs with expansion planned in only two areas: Water Supply in response to an impending NAS report on the program; and Solid Wastes due to new requirements in the Resource Conservation and Recovery Act passed late in 1976. The Budget Documents state that the reduction in outlays is due to re-estimates of outlays from obligations prior to FY 1978. The trend in obligations, in turn, seems to result from re-estimates of unobligated balances in FY 1976. Actual obligations in FY 1976 were almost $100 million less than were estimated in the FY 1977 budget (AAAS–77, p. 80). As we have seen often in other R&D budgets this year, a large amount of these unobligated balances is scheduled for obligation in FY 1977, the middle year in the budget presentation.

Since all components of EPA's budget are presented in terms of the "media" shown in Table 29, it is easy to calculate the proportion of EPA's activities in these areas that are classified as R&D. The right-hand column shows these percentages. The total percentage is based only on the budget for the "media" shown in the table, not on the total EPA budget. There is no inherent "best" ratio of R&D activities to the total program; the appropriateness of the fractions shown could be judged only after an examination of factors such as the objectives of the programs, the stage of development of the field, the technical and societal demands placed on the programs, the activities supported by other public and private agencies, and so on. One thing the percentages show immediately, however, is that although R&D in EPA increases only slightly in the FY 1978 budget, and, in fact, declines in "real" terms, it does much better budget-wise than most other areas. R&D goes from 37.3 percent in FY 1977 to 44.3 percent in FY 1978 of the total EPA activities in the "media" shown.

In addition to its "maintenance-of-effort" stance, the EPA budget materials emphasize an intention to decrease personnel levels. In the Office of Research and Development, a decline in personnel has been occurring since FY 1974. This decrease is directed toward conducting

Table 29. Environmental Protection Agency: "Research and Development" Appropriation[1] (in millions)

	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget	Percent R&D in Total Media Program
Budget Authority:				
Air				
Water Quality	46.8	44.0	39.6	40.5%
Water Supply	43.9	44.2	44.8	30.8%
Solid Wastes	12.3	13.2	15.2	56.9%
Pesticides	4.1	4.1	7.7	31.4%
Radiation	10.9	10.7	10.8	23.9%
Noise	1.7	.8	.8	14.3%
Interdisciplinary	—	—	—	—
Toxic Substances	28.2	26.3	25.8	64.8%
Energy	1.4	1.4	1.4	6.1%
Program Management	100.5	96.4	96.4	100.0%
and Support	$ 15.6	$ 18.4	$ 18.8	25.3%
TOTAL: Budget Authority	$265.4	$259.5	$261.3	44.3%
TOTAL: Obligations	217.3	305.6	260.5	—
TOTAL: Outlays	235.9	294.0	268.0	—

Source: Agency budget justification.

[1] Includes energy R&D which had a separate appropriation in FY 1976 and 1977.

more research extramurally and to increasing positions for other Agency activities.

The Office of Research and Development is responsible for carrying out most of EPA's R&D activities. The budget for the office by "media" is shown in Table 30. This media breakdown is only for budgetary purposes, however. The office itself is divided functionally into five major program areas as shown by the budget in Table 31. The two areas receiving the large increases, Water Supply and Solid Wastes, are located in the Public Sector Activities Program Area.

Let us now look at some of the details in the EPA budget for R&D.

(1) *Solid Waste*. The increase reflects expansion in two areas: munic-

Table 30. EPA: Office of Research and Development Budget by Media (Budget Authority in millions)

Media	FY 1975 Actual	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget
Air	$ 53.6	$ 48.5	$ 43.0	$ 39.6
Water Quality	41.6	44.0	41.3	41.9
Water Supply	5.9	12.7	13.6	15.6
Solid Wastes	5.7	4.1	4.1	7.7
Pesticides	7.1	8.4	8.3	8.3
Radiation	2.6	1.7	0.8	0.8
Noise	–	–	–	–
Interdisciplinary	18.1	28.0	25.9	25.1
Toxic Substances	1.2	1.3	1.4	1.4
Energy	133.1	100.0	96.4	96.4
Program Management and Support	9.2	5.0	7.2	7.2
TOTAL ORD Program	$278.1	$253.7	$242.0	$244.0

Source: Office of Research and Development description.

Table 31. EPA: Office of Research and Development Budget by Program Area (Budget Authority in millions)

Program Area	FY 1975 Actual	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget
Health and Ecological Effects	$ 62	$ 71	$ 64	$ 62
Industrial Processes	27	21	19	18
Public Sector Activities	28	30	30	36
Monitoring and Technical Support	19	27	26	25
Energy/Environment	133	100	96	96
Other (Program Support and Management, etc.)	9	5	7	7
TOTAL ORD Program	$278	$254	$242	$244

Source: Office of Research and Development description.

ipal waste water treatment sludge disposal – primarily the land application of sludges – and the evaluation of resource recovery systems. These two areas were identified for special attention in the Resource Conservation and Recovery Act of 1976. The program is also developing the scientific base for the possible establishment of standards for hazardous waste disposal. Of particular interest is information on the fate and processes of such materials flowing through soils and ground water systems.

(2) *Water Supply*. During calendar year 1977, the National Academy of Sciences is reviewing the Water Supply Research Program. The increase shown is intended for the implementation of the expected recommendations in the NAS report. The areas expected to receive emphasis are (i) determination of the occurence and effects of potential carcinogens in drinking water, (ii) development of monitoring and analytical methods, and (iii) determination of the applicability of bench level carcinogen removal techniques.

(3) *Water Quality*. The Health Effects activity increases from $2.4 million to $3.8 million to develop procedures to identify and characterize pollutants, to develop assessments of the biological impact of substances on living organisms, and to apply these tests to complex effluents. Waste Water Management gets a small increase for urban-runoff research.

(4) *Energy*. Note that all of EPA's activities in energy are classified as R&D. The Health and Ecological Effects Activity increases by 11.4 percent to $39.2 million in order to keep pace with the developing coal gasification and liquefaction technologies.

(5) *Radiation*. The EPA Radiation Program will continue its emphasis on nonionizing radiation. The program focuses on potential biological effects of exposure to electromagnetic radiation – a relatively new, complex, and growing area of concern. Research on ionizing radiation is left largely to other agencies, such as ERDA and NRC.

(6) *Air*. The lone area under this heading not reduced in funding is work on carcinogens. This area is increased from $1 million to $2 million through a reallocation of funds from within the Health Effects Activity. No funds are requested for Stratospheric Modification in FY 1978. This program was established in 1976 to lead a federal interagency program of Biological and Climatic Effects Research (BACER). The objectives of the short-term BACER program are to be achieved during early 1978.

(7) *Toxic Substances*. The Toxic Substances Control Act has resulted in large increases in the toxic substances abatement and control programs, but the R&D program remains level. Toxic substances abatement and control is scheduled for increases of 174 positions and $15.1 million. Although the funding of the R&D program does not change, the focus of the program is being shifted toward support of the Toxic Substances Control Act in areas such as the development of toxicological screening methods for toxic substances to identify which compounds are likely to persist in the environment or have adverse effects on man.

Table 32. R&D in the Department of Agriculture (Budget Authority in millions)

	FY 1976 Actual	FY 1977 Est.	FY 1978 Budget
Agricultural Research Service	$256.5	$279.1	$313.4
Cooperative State Research Service	114.5	129.0	136.7
Forest Service	83.2	90.6	96.4
Economic Research Service	24.7	26.2	28.4
Statistical Reporting Service	1.8	2.2	2.2
Farmer Cooperative Service	1.3	1.3	1.6
TOTAL Agricultural R&D	$482.0	$528.4	$578.7

Source: "OMB Data for Special Analysis P." R&D facilities are excluded.

8. R&D in Some Additional Agencies

a. Department of Agriculture (USDA)

The big news in agricultural R&D is a proposal to establish a competitive grants program in basic research important to meeting the food needs projected to the year 2000 and beyond. This is envisioned as a long-term program in basic research with areas of interest to be identified periodically. The current proposal is for a 5-year program totalling $150 million, with the content and funding to be thoroughly evaluated at the end of this period. For FY 1978, $27.6 million in budget authority is requested for work in four areas related to crop productivity: photosynthesis, nitrogen fixation (the conversion of nitrogen in the soil to usable plant food), genetic engineering to make plants more productive and resistant to insects and diseases, and other forms of plant protection mechanisms designed to reduce dependency on present pesticides.

Competition for these grants will be open to all private and public research institutions in the U.S. The competition will be patterned after the NSF and NIH models in which unsolicited proposals are subjected to "peer" review. Due to the necessity to ensure the eligibility of federal scientists for this program, and to the peculiarities of existing legislation, the program will be administered by a special unit in the Cooperative State Research Service (CSRS), but the appropriation is requested through the Agricultural Research Service (ARS) and is reflected in the large increase for ARS in Table 32. Under existing legislation, federal scientists are ineligible for the competitive research programs in CSRS, but legislation will be requested so that future appropriations for this program can be made to CSRS directly.

It may be recalled that a basic research program in USDA was also a highlight in the FY 1977 budget. So, why all the emphasis again this year? There are two differences between the current proposal and the

previous one: (i) the FY 1978 program is based on competitive grants, while the previous proposal was for research funded through formula grants to state universities and land-grant colleges; (ii) the competitive grants program will be administered separately with its own director. Thus, the current proposal enhances the visibility of the program and expands the number of persons and institutions eligible for support.

Research in USDA is carried out primarily by federal scientists in the Agricultural Research Service and through grants to State Agricultural Experiment Stations in land-grant universities (operated through the Cooperative State Research Service). Including the new competitive grants program described above, budget authority for these major research programs increases by 9.5 percent in FY 1978 to $456 million. Existing ARS and land-grant programs (CSRS) will get an increase of $13 million: about $5.3 million for ARS and $7.8 million for CSRS. ARS will strengthen its basic research program in photosynthetic efficiency and nitrogen fixation. The State Agricultural Experiment Stations will increase research in beef, feed grain and soybean production, as well as emphasize forage, range, and pasture research.

b. Agency for International Development (AID)

The OMB data in Table 13 show that support for R&D in AID is scheduled for a large increase in FY 1978, from $27.3 million to $42.2 million. The analysis of R&D in the AID budget is complicated by definitional problems and by the fact that activities that could be regarded as R&D are spread among many bureaus and organizations whose primary focus is on regions or functions of which R&D is only an incidental part. Further complicating the picture is a current examination by AID officials of the activities classified as R&D. A narrow definition now includes programs in a few bureaus, such as the Technical Assistance and Population Bureaus. It may be broadened to include certain activities in the Geographical Bureaus as well as new activities initiated in response to recent legislation, such as Title XII of the Foreign Assistance Act of 1961 as amended in the Act of 1975, which is concerned primarily with problems of food and nutrition and is known colloquially as "Famine Assistance and Freedom from Hunger."

The analysis we have been able to make in the time available indicates that the Population Bureau accounts for a major portion of the increase in AID R&D; health and education R&D show large percentage increases, but they are only small parts of AID's total R&D. Table 12 shows that AID support for R&D at colleges and universities also increases in FY 1978, doubling the level in FY 1977. This large increase comes in AID's general support for R&D, however, and not under two specific authorities AID has for R&D at colleges and universities.

Title XII of the Foreign Assistance Act specifically calls for the participation of land-grant, sea-grant, and other universities which have a "demonstrable capacity" in development and technical assistance programs through established research, extension and training activities.

Table 33. Selected Research in AID (Obligations in millions)

	FY 1977 Estimated	FY 1978 Budget
Technical Assistance Bureau		
Food and Nutrition	$16.1	$14.7
Health	1.4	2.9
Education and Human Resources	.8	1.3
Selected Development Activities	2.0	1.8
TOTAL Research, Technical Assistance Bureau	$20.3	$20.7
Population Bureau	$ 8.4	$17.6
Program Coordination Bureau	$ 1.0	$ .8
Section 211(d) Activities in Colleges and Universities	$ 2.5	$ 2.2

Source: AID officials.

Grants to colleges and universities under this authority are estimated to increase by only $3 million in FY 1978, a doubling, but small compared to the $15 million increase shown in Table 12. This program is included in the Food and Nutrition activity in Table 33. Additional authority is provided by Section 211(d) of the Foreign Assistance Act as amended, which is aimed at strengthening the capacity of institutions in the United States to develop and carry out programs concerned with the economic and social development of less-developed countries. Funds for activities based on this authority decrease slightly in FY 1978, going from $2.5 million to $2.2 million.

Chapter 4

The Future Outlook for R&D

In this chapter we will try to see what the FY 1978 budget implies for the future and to identify some of the policy issues that will determine the size and nature of future R&D budgets. Future budgets are always more important than past or current budgets, from the standpoint of R&D policy. Nothing can be done about the past, and current budgets move through the cycle so fast that time is usually too short for new or different views to catch up. To influence the course of R&D budgets one would like to forecast the future trends, assess the implications, propose preferable alternatives, and then mount an appropriate campaign, early in the budget cycle, to secure their adoption.

This is easier said than done. There are no official forecasts of future R&D budgets. The FY 1979 figures in President Ford's FY 1978 budget give some clues for 1 year ahead. The 5-year projections for some agencies (for example, Defense and NASA) give a few further indications, but meaningful data are scarce and always have the qualification that future budgets depend on future decisions. The best of projections can easily be wrecked when unexpected changes in the current budget cycle invalidate the starting point or the assumptions on which they were based. The whole notion of budget policy analysis seems doomed to failure before it starts – there is so little to get hold of and no firm place to begin. The only answer is to construct an artificial baseline, or perhaps more than one, by projecting what the budget would be like under certain assumptions and using this imaginary forecast to assess implications and develop preferred alternatives.

Baseline budget projections play necessary roles in the actual working of the budget process. They are needed to forecast financial requirements in gross terms. Projections for individual programs are used in making the trade-offs needed to set agency budget ceilings within the government's overall fiscal plan. Individual agencies need their own sets of projections for planning their programs and their budget campaigns. Baseline budget projections are most useful when they are directly

associated with a specific program plan; with such projections one could aspire to a logically satisfying analysis of the program effects of alternative budgets. Unfortunately, projections linked to future program plans are rarely available, especially to interested parties outside the official process. When such plans exist, they seldom have official approval, and their potential for creating controversy or embarrassment – they're bound to be criticized as either too high or too low – is a strong incentive for keeping them under wraps. Even the statutory requirements that 5-year projections accompany each appropriation bill have not been very successful in smoking out real 5-year budget plans. It would be difficult indeed to get anyone in the government to go on record with an official projection of R&D budgets.

One government study that did project future R&D spending by all sectors of the economy is in an interesting NSF publication entitled *1985 R&D Funding Projections*. This study prudently eschews any judgments on programmatic needs, makes no estimates for individual agencies or programs, and does not even attempt year-by-year projections. It makes "point" estimates of total R&D spending in safely distant 1985 for the federal government in total and for the other principal sectors of the economy. It relies heavily on Bureau of Labor Statistics long-range projections of purchases of goods and services, other long-range economic forecasts, and historical ratios of R&D spending to sales or purchases. The result is a useful guess at where R&D funding may be going. As we shall see, the average rate of increase of total federal R&D spending resulting from this NSF analysis is in the same ballpark as one of the imaginary projections we will construct below.

As outside analysts, we have the advantage of being free from official inhibitions; hence we can freely make some projections for what they are worth. But we have the disadvantages that we don't have programs to go with our projections and don't have the capability to investigate alternatives and implications in any depth. What we can do is to lay down some baseline alternatives, state the rather simple assumptions on which they are based, and start to raise some of the policy issues and implications which should be addressed by responsible officials and the scientific, technical, and public policy communities. Ours is the modest goal of presenting a framework and listing questions. The answers will have to come out of thoughtful discussion and further study by many wise people.

We will begin by looking at the prospects for R&D in the federal budget in FY 1979, first at where the numbers may go and then at what the impact may be of the new zero-base budgeting procedures which the Carter administration plans to use. Then we will scan the horizon to FY 1982 and present two baseline projections for reference. After noting briefly the importance of some unanswered questions on the support of R&D by industry, we will end by summarizing some of the key policy issues that deserve further discussion and study.

A. Outlook and Issues for FY 1979

We are on somewhat firmer ground in projecting the FY 1978 R&D budgets into FY 1979 than we will be when we get to our projections for the 5-year period FY 1978 through FY 1982. For one thing, next year's budget is always largely determined, in fact if not in theory, by this year's budget. Plans, programs, and commitments already in place are always a powerful force for stability; this is not entirely a matter of bureaucratic inertia – the reasons justifying prior commitments are usually still valid a year later. Therefore, even though the FY 1979 budget will undergo review by the new administration, using its new zero-base budget procedures, it seems reasonable to expect the R&D programs projected for FY 1979 in President Ford's FY 1978 budget will generally survive in President Carter's FY 1979 budget; the changes are likely to follow the same pattern as the Carter FY 1978 budget amendments – a few significant policy changes and some fine tuning of details, but with most of the effort left to proceed as previously planned.

A second crutch for our FY 1979 projections is the fact that President Ford included FY 1979 figures in his FY 1978 budget. These FY 1979 estimates are complete in the sense that they cover the entire budget, but not in the sense of providing the same degree of detail as given for FY 1978. There are estimates for the R&D appropriations in Defense, NASA, and some other agencies. Agency total figures give some basis for estimating R&D amounts for other agencies like NSF where virtually all of the expenditures are classified as R&D. But no "Special Analysis P" was prepared for FY 1979; we have had to make our own estimates of the R&D amounts for the major agencies and in total, based on the data available.

Table 34 shows our FY 1979 estimates for two cases, A and B, compared to the FY 1978 budget as amended by President Carter. Both the A and the B estimates are based on a construction of the amounts of budget authority for R&D that would have appeared in a "Special Analysis P" of President Ford's FY 1979 estimates, with adjustments to project into FY 1979 the effect of President Carter's FY 1978 budget amendments and to give effect to the additional assumptions noted below. The A and B estimates are intended to illustrate high and low ends, respectively, of a range of FY 1979 budgets that might reasonably be expected.

For Defense, Case A assumes a decision by the Carter administration, after its reevaluation of defense programs and posture, to head back to the level of R&D projected by President Ford rather than continuing in FY 1979 a reduced level corresponding to the amended FY 1978 budget; our estimate takes DOD R&D within $50 million of the amount projected for FY 1979 by President Ford. Case B, on the other hand, assumes the Ford FY 1979 figures will be reduced by the same amount as in FY 1978, and also that the Ford administration policy of

Table 34. Federal R&D Budgets: FY 1979 Projections (Budget Authority in billions)

Current dollars	FY 1978 (Amended Budget)	FY 1979 Projected "A"	FY 1979 Projected "B"	Percent Change "A"	Percent Change "B"
Conduct of R&D:					
Defense	$12.20	$13.40	$13.10	+10.1%	+7.6%
ERDA	4.14	4.55	4.39	+10.0%	+6.0%
NASA	3.85	4.29	4.24	+11.4%	+10.1%
NIH	2.29	2.68	2.58	+17.2%	+12.7%
NSF	.77	.84	.81	+9.0%	+6.0%
All Other	3.04	3.34	3.22	+9.0%	+6.0%
Total, Conduct of R&D	$26.29	$29.10	$28.35	+10.9%	+7.8%
R&D Facilities (total)	1.44	1.47	1.44	+2.1%	–
Total R&D	$27.73	$30.57	$29.78	+10.2%	+7.4%
Included above:					
Basic Research	$ 3.06	$ 3.37	$ 3.24	+10%	+6%
R&D at Colleges & Universities	3.18	3.50	3.37	+10%	+6%

Source: FY 1978: Data for "Special Analysis P," Revised (budget authority estimated from obligation data); FY 1979: authors' estimates.

annual real growth of 10 percent for research and 5 percent for exploratory development will be replaced by a policy allowing only increases to offset inflation. As indicated, however, even under our Case B, Defense R&D would get an overall increase of 7.6 percent, which would be 1.6 percent greater than the assumed 6 percent inflation.

For ERDA, our Case A projects a continued overall increase of 10 percent. This assumes a further major increase in federally funded technological efforts to deal with the energy problem; the increase would be more than 10 percent in the areas emphasized if further cutbacks are made in the breeder reactor and fusion programs as presaged in the Carter FY 1978 budget amendments. Case B would provide an increase of only 6 percent, equal to the assumed inflation rate. This projection may be more realistic if the new Carter administration energy policy continues to stress non-R&D actions and de-emphasize long-term energy R&D. It also seems possible that ERDA FY 1979 budget authority requirements might be held down because of excessive carry-over from the large Congressional and Presidential increases in FY 1977 and FY 1978.

The NASA estimates include the built-in increases associated with the space shuttle reflected in the NASA budget plan in the Ford FY 1978 budget, plus an estimate of about $30 million to carry forward in FY 1979 the increases in the FY 1978 Carter amendments. Case A includes an

additional $50 million to cover the possibility that the Carter administration might want to proceed in FY 1979 with some of the future initiative options available in NASA's long-range planning.

For NIH we have assumed that the amount shown for the Carter budget in FY 1978 will in fact be increased by Congress to give NIH about a 10 percent increase over FY 1977; an annual increase of this amount has been more or less standard practice in recent years. Our Case A assumes a further 10 percent increase in FY 1979; Case B assumes that the increase will be held to the inflation rate of 6 percent.

In the case of NSF and "all other," and for the separate memorandum entries for basic research and R&D at colleges and universities, we have assumed a 10 percent increase in Case A and a 6 percent increase in Case B. Thus, our high case assumes continued real growth of 4 percent; our low case assumes a new policy that allows overall increases equivalent only to the increase due to inflation. For R&D facilities we have included the same dollar level as FY 1978 in Case B, on the assumption that there should be some falling-off in FY 1979 in ERDA's $1 billion level which would offset increases in other agencies needed for facilities and capital equipment. Case A adds another $30 million for this purpose.

In total, then, our projections indicate FY 1979 increases of between 7.4 percent and 10.2 percent over the FY 1978 budget as amended by President Carter. The lower end of this range is only 1.4 percent above the assumed rate of inflation; one would suppose that this small increase could be handled within the overall FY 1979 budget without too much strain. A total at the high end of the range might present a problem if the economic or political situation next fall dictates a tight budget. In that case, some of the planned program increases in Defense, ERDA, or NASA, and the policy of continuous growth for basic and other research would have to be reconsidered.

B. What About Zero-Base Budgeting?

R&D budgets for FY 1979, like all others, will have to run the gauntlet of zero-base budgeting. President Carter's budget message revising the FY 1978 budget reaffirmed his previous commitments to zero-base budgeting and promised that his "future budgets will reflect detailed, zero-based reviews of federal spending programs." The actual changes in budget procedures to be required are not known at this writing, but the question can fairly be asked how the outlook for R&D budgets in FY 1979 is likely to be affected.

Changes in the budget process could lead to different answers, if the new processes raise new questions or are somehow slanted in a new direction. But if both the old and new processes judge programs fairly, the bottom line results should be the same and the only impact of the

change would be the additional wear and tear on the actors in the process. The new Congressional budget process, for example, does not seem to have had a direct influence on the R&D outcome in FY 1977; the advance consideration of defense funding levels may have had some impact, but it seems likely that the authorization and appropriations committees would have come to about the same results anyhow. Will zero-base budgeting likewise be just a procedural change for R&D? Or does it spell new trouble for the R&D and its supporters?

The conclusion of the discussion that follows will be that new zero-base procedures as such are not likely to have a significant effect on R&D budget results unless they are coupled with other changes in policy, decision criteria, or attitudes which do affect the actual decisions. To explain this view, a short explanation of the zero-base budget concept and how it might operate in R&D is first in order. We should note, in passing, that a related concept is receiving attention in Congress—so-called "sunset legislation" that would terminate government programs automatically at stated times unless a Congressional reevaluation leads to positive action to continue them.

Zero-Base Budgeting (ZBB) has two aspects. One is an approach or attitude in budgeting. The other is a set of detailed procedures intended to ensure that the ZBB approach and attitude are taken by managers and reviewers in the budget-making process. The ZBB approach and attitude are simply that *all* proposed expenditures of each estimate should be challenged and reviewed in the budget process, not just incremental changes in the amounts approved in previous years. The detailed procedures for doing this are something else. In principle they could be simply a strong injunction, strongly enforced, to all agencies and managers that they must in fact apply the ZBB approach and attitude in every budget decision that they make. But, in fact, interest is now sharply focussed on a specific type of detailed procedures developed several years ago in the TRW company and applied in the State of Georgia budget while President Carter was Governor. Current indications are that procedures like these are what the Carter administration intends to require the Executive Branch to follow in the preparation of the FY 1979 budget.

The basic bible of ZBB is the book, *Zero-Base Budgeting*, written by Peter A. Phyrr, which explains in detail the procedures he helped install at TRW and later helped transplant to Georgia. These procedures prescribe a "bottom-up" system of budgeting, that is, budgets are first developed at every working level by the responsible managers. Then budgets are grouped into a predetermined set of "decision packages," again usually corresponding to the areas of responsibility of specific managers. Each successive level of management is then required to rank in priority order the decision packages for which that manager is responsible, and to make his recommendations to the next higher level. Ultimately the top decision authority makes the final decisions on the

basis of the priority recommendations coming up the line, review of the documentation of the decisions made at lower levels, and any other considerations considered pertinent.

The initial response of the federal budget community to ZBB has been cool and skeptical. Many have been quick to point out that complete rather than incremental review of all activities has been specifically required of all agencies and of the OMB staff by every budget director in recent years. Oldtimers can even remember Director Maurice Stans using the words "zero-base budget." Others have questioned the practicality of the detailed procedures and the validity of some of the concepts on which they are based. The idea of a complete bottom-up, zero-based budget for the entire federal establishment conjures up visions of unbelievable masses of paper work; but critics should not forget the unbelievable amount of paper work in the present process. A more basic criticism is that priorities of federal programs, or within programs, generally can't be meaningfully ranked in a linear priority order; there are different kinds of priorities to be considered, and some low-priority activities have to be carried out regardless because of legal requirements or other overriding considerations. It is also pointed out that the degree of success of ZBB in Georgia seems to be somewhat hard to demonstrate. One study found that little change appeared in the budget, but that some value had resulted from officials becoming better aware of the activities and needs of each organizational unit; President Carter and OMB Director Lance have also stressed the benefits of ZBB for reorganization planning and the setting of overall priorities. Finally there is the general Washington skepticism of new "magic systems" and especially of the suggestion that a single new system can be expected to be applicable to the whole gamut of activities covered in the federal budget. But the President and his Director of OMB have left no doubt that new ZBB procedures will be used in preparing the FY 1979 budget. We are heading for an experimental test on a grand scale.

What does this mean for R&D? The idea of a total, not incremental, challenge to R&D budgets is not new; in fact it is already the rule rather than the exception. Controversial development projects, such as SST's, B–1's, space shuttles, and so on, are challenged in their entirety year after year. Agency heads faced with the customary overly tight budget ceilings from OMB, are forced each year to consider what programs might be eliminated entirely in order to make room for necessary new items. The authorizations, and especially the appropriations committees in Congress typically question the basic need and total budgets for each program.

It is true that the language used in budget reports and the rhetoric of R&D advocacy often give a different impression. In areas like basic research, health research, and other categories of R&D where there are too many projects to be considered individually, discussion is often in terms of increases and decreases, "real growth," or other incremental features of the budget. This may reflect an absence or avoidance of zero-

base thinking in some cases, but in our view it reflects primarily the absence of any other simple, understandable way of explaining the needs or justifications of particular budget amounts in these types of R&D budgets. The ultimate point is that regardless of the procedures used – zero-base or other – budget decisions on program levels in research and other "level of effort" areas will always come down to a matter of judgment. One relevant and legitimate factor in even a zero-base judgment can be the level of previous budgets.

These considerations suggest that the introduction of ZBB need not in itself affect materially the R&D decisions in the FY 1979 budget. It will be a whole new ball game, however, if the introduction of zero-base budgeting is accompanied by rigid new criteria for budget justifications or a less friendly policy attitude toward research and development. For example, if it is linked to requirements for economic pay-off or other narrow tests of relevance, zero-base budgeting might become a battle flag in a crusade against large or larger budgets for basic research and general technology development. But such a linkage is not inherent in zero-base budgeting, and there has been no indication to date that the Carter administration intends to revert to reliance on economic or other narrow tests of relevance of the sort that sometimes characterized official policy during the Johnson and Nixon administrations. The key point will be the Carter administration's policy attitude toward R&D. It will use its zero-base budget procedures, whatever they turn out to be, to effectuate its policies; the budget procedures will not by themselves create the policies on R&D.

C. Imaginary 5-Year Projections

Now let us resume our speculations about the future trends of federal R&D budgets. Beyond FY 1979 we really have almost nothing tangible to go on except a hunch that the next 5 years will not see a major reversal of trends now apparent. With this as one assumption, and the blind guess that no big new program will erupt as another, we will project R&D budgets through FY 1982 on two bases that correspond to and extend our "A" and "B" estimates for FY 1979. These are not budgets, but imaginary projections. The "Case A" and "Case B" projections in Table 35 are again intended to indicate the range of R&D funding that seems reasonable to expect, based on the policy assumptions noted. To avoid the added complications of trying to forecast long-term inflation rates, both sets of projections are in constant dollars after FY1979.

For Defense R&D, Case A assumes a decision by the Carter administration to adopt the same outlook and approach in military R&D as was advocated and projected by the Ford administration, that is, a hard drive to maintain unequivocal technological superiority over the Soviet Union. The specific projects might well be different, but it seems

reasonable to assume that the total level of military R&D would be on the same track as projected in the Ford FY 1978 budget in the period FY 1980–82. This would mean a real dollar boost of a billion dollars in FY 1980 and a leveling off thereafter. The price of unequivocal technological superiority is high! In Case A the policy of real growth in research and exploratory development at rates of 10 percent and 5 percent per

Table 35. Federal R&D Budgets: 5-Year Projections (Budget Authority in billions; FY 1979–82 estimates in constant FY 1979 dollars)

	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982
Case "A"					
Conduct of R&D:					
Defense	$12.20	$13.40	$14.44	$14.41	$14.28
ERDA	4.14	4.55	4.73	4.73	4.73
NASA	3.85	4.29	4.38	4.42	4.50
NIH	2.29	2.68	2.79	2.90	3.01
NSF	.77	.84	.88	.91	.95
All Other	3.04	3.34	3.47	3.61	3.76
TOTAL, Conduct of R&D	$26.29	$29.10	$30.69	$30.98	$31.23
R&D Facilities (total)	1.44	1.47	1.47	1.47	1.47
TOTAL R&D	$27.73	$30.57	$32.16	$32.45	$32.70
Included above:					
Basic Research	$ 3.06	$ 3.37	$ 3.50	$ 3.64	$ 3.79
R&D at Colleges & Universities	3.18	3.50	3.64	3.79	3.94
Case "B"					
Conduct of R&D:					
Defense	$12.20	$13.10	$13.10	$13.10	$13.10
ERDA	4.14	4.39	4.39	4.39	4.39
NASA	3.85	4.24	4.23	4.12	4.00
NIH	2.29	2.58	2.58	2.58	2.58
NSF	.77	.81	.81	.81	.81
All Other	3.04	3.22	3.22	3.22	3.22
TOTAL, Conduct of R&D	$26.29	$28.34	$28.33	$28.22	$28.10
R&D Facilities (total)	1.44	1.44	1.40	1.30	1.20
TOTAL R&D	$27.73	$29.78	$29.73	$29.52	$29.30
Included above:					
Basic Research	$ 3.06	$ 3.24	$ 3.24	$ 3.24	$ 3.24
R&D at Colleges & Universities	3.18	3.37	3.37	3.37	3.37

Source: FY 1978: Data for "Special Analysis P," Revised (budget authority estimated from obligation data); FY 1979–82: authors' estimates.

year, respectively, is assumed to continue in force through FY 1982.

Our Case B for military R&D is intended to illustrate the possibility that the Carter administration might decide to take a strong but less all-out approach in developing new military capabilities and technologies. After the small (1.6 percent) real overall increase provided in our B estimate for FY 1979, we have assumed a level budget in constant dollars for the rest of the period. This assumes that needed major new projects would be phased into the budget as others are completed and that no further real increases would be provided for technology-based R&D.

For ERDA, Case A assumes that FY 1980 will be one more year of real net increase (almost 4 percent) for conduct of R&D, and that the federal energy R&D program will then level off in terms of constant dollars. This projection is based on the notion that the major energy development programs of the Carter administration will be established in FY 1978 and FY 1979 and that a continually increasing R&D budget will not be required to sustain them in succeeding years. By FY 1981, short-range development programs should be moving out of R&D into the private sector for demonstration and implementation. Longer-range programs, like fusion power development, should by then be stabilized for the long pull. Unless there is some unforeseen breakthrough to exploit, these assumptions seem reasonable. Case B for ERDA assumes that the leveling-off comes a year earlier; it could still provide for a strong, continuing program of energy research development.

The NASA projections are based on published estimates of run-out costs of the program levels assumed in the Ford FY 1978 budget, as modified by the Carter amendments. Case B adds a small "wedge" in the FY 1980–82 period representing the amounts that would normally be needed for new program starts as other programs are completed. The resulting estimates show a real decrease of about 5.6 percent in the total NASA budget. Case A is the same except that provision has been made for a major new space initiative, such as development of a permanent orbiting space station. Even with $500 million for such an initiative in FY 1982, the total NASA budget would grow less than 2 percent per year in constant dollars from FY 1979 to FY 1982.

In the case of NIH, our Case A assumes continuation through the entire period of annual increases at about the same rate as have eventuated in recent years after the annual tussle with Congress; that is, about a 10 percent per year increase in current year dollars which translates into a real increase of 4 percent per year, assuming a 6 percent rate of inflation. Case B assumes that the budgeteers finally succeed in holding the line at cost of living increases only.

For NSF, we have similarly bracketed the possibilities. Case A assumes that the need for continued real increases will continue to be recognized with real growth of 4 percent overall each year. This would permit a real growth in actual research support of more than 4 percent if support activities within the NSF R&D total can get along with a smaller

real increase. In Case B we assume that the whistle blows on continued real growth in FY 1979, and that NSF funding for conduct of R&D remains level in constant dollars thereafter.

Case A and Case B for the "all other" category have been projected on the same basis as NSF. Requirements for the many agencies involved will undoubtedly fluctuate, but the total is not likely to fall outside the range of our two estimates.

For R&D facilities our Case A assumes that needs will emerge that require continued funding in constant dollars at the level reached in our FY 1979 "A" estimate. This level should be ample for all R&D agencies since it has been boosted in FY 1978 and FY 1979 by the inclusion of almost a billion dollars for ERDA demonstration and other facilities, the needs of which should decline as capital investment programs are completed and demonstration plants are succeeded by operational plants in the private sector. Case B assumes that a faster decline in ERDA's needs would permit the total for R&D facilities to decrease in constant dollar terms.

The projection shown for total basic research and total R&D at colleges and universities have arbitrarily been based on the same assumptions as used for NSF; 4 percent per year real growth in Case A; zero real growth in Case B. There is no inherent reason why the same rates of change should apply in each of these cases. Our projections in this instance, as in others, serve chiefly as a starting point for asking what the impact would be of continued growth at the rate suggested, of no growth, or of growth (or decline!) at some other rate.

The total of all our Case A estimates would result in an overall increase for R&D of $2.1 billion or 7 percent in constant dollars in the FY 1979–82 period, an average increase of 2.3 percent per year. This comes out somewhat less than the 2.6 percent average annual real increase that would occur under the 1985 projections in the NSF study. Our Case B shows a decrease of $0.5 billion or 1.6 percent over the period, resulting from our restrictive assumptions on NASA, the postulated decline in R&D facilities, and the assumption of no change from the assumed FY 1979 levels for all other programs. The spread between our high and low projections grows from $0.8 billion to $3.4 billion in the FY 1979–82 period. Unless there are major new policy discontinuities, compelling new priorities, or drastic external upheavals, this wedge appears to set the likely fiscal boundaries of policy choices on federal R&D in the next 5 years.

D. The Relevance of Industry R&D

The subject and focus of this report and its predecessor last year have been the federal government's budgets for R&D. Except for presenting a few available statistics on the national pattern of R&D funding, we have not attempted to examine trends or issues in R&D funding by

other sectors – industry, universities, private foundations or state and local governments. This is a limitation that must be transcended in any full consideration of the future outlook. Federal R&D budgeting, and certainly federal R&D policy, must take account of what support the other sectors can, will, and should give to R&D. The AAAS itself is as interested in R&D funded by industry, universities, and others as in federal R&D.

The trends and role of industry funding of R&D are especially pertinent to our 5-year look at the future of federal support for R&D. Some of the interactions between federal and industry spending for R&D are the following:

(1) *The pattern of responsibility for financing R&D in areas of joint federal and industry interest.* Energy R&D is an obvious major example. How far should the federal government go in direct support of R&D in fields that are traditionally the domain of private industry or where individual industries or firms will be direct beneficiaries?

(2) *The mechanisms of financing R&D in the areas of joint interest.* Direct federal expenditures will have one kind of impact on federal R&D budgets, loan programs another, and off-budget enterprises like the Energy Independence Authority twice proposed by President Ford and now rejected by President Carter, still another. Tax incentives for particular types of R&D might achieve some of the same results without appearing at all in the traditional budget totals. These so-called "tax expenditures" have been receiving increasing attention by Executive and Congressional budget authorities.

(3) *The two-way feedback effects of R&D expenditures by government and industry.* If, for reasons of urgency or for other reasons, the federal government mounts a major R&D effort, does this drive out industry financing of R&D in the same areas? Or, if the government bows out of R&D in a particular field, will industry seize the opportunity to increase its support?

(4) *The federal role in enhancing innovation and technological advances in the civilian economy.* It is now widely maintained that the United States as a nation is falling behind other nations in the rate and quality of technological advance to such a degree that our competitive economic position may be threatened. Will or should the federal government support a major R&D compaign to reverse this trend?

The unknowns implicit in these interactions deserve and are receiving increased attention. For the more narrow purposes of this report, we note their relevance to future federal R&D budget trends and include them among the important questions and issues for further discussion and study.

It is worth noting that while some data on R&D funding by industry does exist, there is, of course, no document comparable to the *Budget of the United States* that gives up-to-date information on current and planned spending. Two annual NSF reports, *Research and Development in Industry* and *National Patterns of R&D Resources* provide useful statistics.

Table 36. Industry Spending for R&D: 1974 and 1975

Industry	Total R&D Funds		1975 R&D Funds by Source	
	1974	1975	Federal	Company
TOTAL	$22,399	$23,535	$8,761	$14,775
Food & Kindred Products	294	318	1	318
Textiles & Apparel	69	64	1	62
Lumber, Wood Products & Furniture	64	68	†	†
Paper & Allied Products	237	253	1	252
Chemicals & Allied Products	2,377	2,650	240	2,411
Industrial Chemicals	1,320	1,459	227	1,232
Drugs & Medicines	701	804	†	†
Other Chemicals	356	387	†	†
Petroleum Refining & Extraction	623	700	31	669
Rubber Products	290	288	30	258
Stone, Clay & Glass Products	187	186	1	184
Primary Metals	311	365	9	356
Ferrous Metals & Products	158	178	2	176
Nonferrous Metals & Products	153	187	8	180
Fabricated Metal Products	292	311	15	296
Machinery	2,482	2,659	373	2,286
Office, Computing & Accounting Machines	1,546	1,662	302	1,360
Electrical Equipment & Communication	5,496	5,531	2,515	3,017
Radio & TV Receiving Equipment	51	43	†	†
Electronic Components	450	470	218	252
Communication Equipment & Communication	2,979	2,936	1,285	1,651
Other Electrical Equipment	2,016	2,082	†	†
Motor Vehicles & Motor Vehicles Equipment	2,394	2,339	335	2,003
Other Transportation Equipment	31	28	3	25
Aircraft & Missiles	5,318	5,724	4,527	1,198
Professional & Scientific Instruments	989	1,032	181	851
Scientific & Mechanical Measuring Instruments	116	125	26	99
Optical, Surgical, Photographic & Other Instruments	873	907	155	751
Other Manufacturing Industries	174	189	†	†
Nonmanufacturing Industries	771	830	495	335

Source: National Science Foundation, Science Resources Studies Highlights, October 27, 1976 (NSF 76-324).

† Not separately available but included in total.

Table 36 summarizes some of the data on R&D in industry for 1974 and 1975 that will appear this spring in the former; Table A–4 in the Appendix summarizes some estimates for 1976 from the most recent edition of the latter. NSF data on industry R&D are collected and compiled by the Bureau of the Census on the basis of special questionnaires sent to industry for this purpose.

A major new data resource on industry-funded R&D has recently become available. The Security and Exchange Commission (SEC) now requires companies to file their R&D expenditures as a separate line item in the official annual report known as "Form 10–K" that all public corporations must file each year. These reports are publicly available at the SEC offices, but the SEC does not summarize or analyze the data on R&D. Last year the magazine *Business Week* arranged to have a tabulation made of the Form 10–K data on R&D. In its June 28, 1976, issue, *Business Week* published the statistics on the 1975 R&D funding of the 730 companies that reported R&D as a separate item and have sales of $50 million or R&D expenditures of more than $1 million. This is the first publicly available summary of industry funding of R&D by industrial companies; the NSF–Census data are collected on a confidential basis and published only by types of industry. The *Business Week* figures are presumably quite reliable, since the 10–K reports on each company's official financial position could be subject to audit. It is noteworthy that the *Business Week* statistics totalled $14.5 billion, which is gratifyingly close to the NSF–Census figure of $14.8 billion that appeared 3 months later. It is to be hoped that if not *Business Week* then NSF, or perhaps other organizations that have developed estimates in the past (McGraw-Hill Publications Company and the Battelle Memorial Institute, for example) will mobilize the effort needed to provide an annual summary and analysis of the Form 10–K data.

What can be said about future trends in support of R&D in industry? Not much with a solid basis under it. It seems to be generally believed that industry is increasing its R&D funding, especially energy related R&D, but it is not clear whether there is substantial real growth. The analysis in the NSF study *1985 R&D Funding Projections*, mentioned above, arrives at a projected annual real rate of increase of 3.5 percent. A cooperative effort by the AAAS, industry, and government might shed more light on likely trends and future prospects in this vital area.

E. Questions and Issues

Now let us pull together some of the principal questions and issues that emerge from our analyses of R&D in the FY 1978 budget and our projections for FY 1979 and through FY 1982. First we shall note some general questions that should be considered for each of our projections; then we will present more specific questions which we believe should be pondered, discussed, and perhaps debated by the scientific, technical,

and public policy communities and the responsible officials in government. In going down this list of questions, one should already have in mind the final ones: Are the questions we have listed the real or most important ones? What other equally or more important questions should be considered?

1. General Questions

For each major R&D program, a complete agenda would cover the validity or reasonableness of the baseline projections; their many implications; the alternatives that should be considered and the reasons why they might be preferred. More specifically:

a. VALIDITY OR REASONABLENESS. Are there substantial reasons for anticipating higher or lower levels than those projected in Case A and Case B above? Are the assumptions on which the projections are based reasonable? What different or additional assumptions should be used to give more realistic baselines?

b. IMPLICATIONS. If future R&D budgets approximate Case A or Case B, what would be the implications for
   (1) the goals and objectives of the R&D programs?
   (2) the goals and objectives the R&D program is intended to serve?
   (3) the advancement of science and technology?
   (4) the national economy?
   (5) the position of the United States in the world vis à vis
      (a) national security?
      (b) competitive position in world trade?
      (c) international cooperation in science?
      (d) international competition in science?
   (6) the institutions that perform R&D:
      (a) universities?
      (b) national laboratories and other government R&D installations?
      (c) contract research centers and nonprofit institutions?
      (d) industry R&D organizations?
   (7) the future capabilities of the United States in science and technology?

c. PREFERRED BUDGET PROJECTIONS. What budget levels should be approved for the years covered by the projections? What are the reasons for supporting the preferred levels and opposing the others?

2. Some Specific Questions

In formulating the following questions, the aim has been to identify significant policy questions of general interest, as distinguished from issues on specific program details. Also we have tried to list *operative*

questions, that is, questions on which actions can or must be taken in the budget process for FY 1979 and following years, or questions which may directly influence decisions on R&D budgets. The order of questions does not indicate relative priority; any provocative language is intended to stimulate discussion, not to imply answers.

a. BASIC RESEARCH. Should the FY 1979 and succeeding budgets be based on a policy of continued real growth in basic research? Why? At what rate? For how long? To what limit? Should such a policy apply to only some basic research programs? Only some agencies? Only some performers? On what basis should the policy be applied to some basic research activities and not to others?

b. NEED FOR GROWTH. In R&D areas where further real growth in budget levels appears warranted, what are the basic rationales for continued growth? Do these rationales support the need for an increase each year in the *rate* at which the output of R&D – scientific and technological advances – are being produced? Is the basic reason to regain earlier levels eroded by inflation? To meet specific unmet needs more quickly? Or are there considerations of national economic or social policy which indicate that a significantly higher level of R&D effort is in the national interest?

c. MILITARY R&D. Should the FY 1979 and succeeding budgets for national defense R&D be based on the policy in President Ford's FY 1978 budget of maintaining a posture of "unequivocal technological superiority"? Does this policy, or an acceptable restatement of it, require increases in FY 1979 and FY 1980 of the magnitude illustrated by our Case A? Should the policy of annual real growth of 10 percent in DOD research and 5 percent in exploratory development be continued in FY 1979? In succeeding years?

d. SPACE. Should any fundamental changes be made in the current NASA long-range program plan? Should any major new initiatives – for example, a permanent orbiting space station – be considered for initiation in the FY 1979–82 period?

e. ENERGY R&D. Should energy R&D programming be adjusted to constrain R&D on plutonium-based energy systems or should any constraints considered necessary be applied only to demonstration and operational undertakings? Should R&D on longer-term energy options (e.g., fusion power) be conducted at an all-out, a normal, or a constrained level? Should actual spending levels for energy R&D be permitted to rise to or above the sharply increased appropriation levels of FY 1977 and FY 1978, or can the essential needs of the program be met by carry-over and judicious use of available funds, without increasing the total level?

f. INDUSTRY ROLE IN ENERGY R&D. What should be the respective

R&D roles of government and industry in the Carter administration energy program? Should there be direct government financing, guaranteed loans, cost-sharing, tax incentives; or purely private funding of developmental and demonstrational plants in areas the government wants emphasized? Should federal R&D funding be curtailed to avoid driving out private financing? Should the idea of an off-budget agency like the Ford administration's proposed Energy Independence Authority be reconsidered?

g. HEALTH RESEARCH. What are the true merits of each of the several sides of the traditional annual dispute over the level and composition of the NIH budget? Should the policy be one of continued increases each year for the indefinite future? Can some meaningful guidelines be developed for budget planning that will permit NIH to plan and operate without the continuing trauma of conflicting guidance from the administration and Congress?

h. ENVIRONMENT. What budgetary actions on environmental R&D will help establish a more effective relationship between R&D on the one hand and regulatory and other environmental programs on the other?

i. CIVILIAN ECONOMY. Should special new initiatives be included in future federal R&D budgets to help push technological development and innovation in the civilian economy in order to increase productivity and improve the competitive position of the United States in international markets? Should this be done by direct federal funding of R&D in industry? By loans? By an expanded "Independent R&D" (IR&D) program? By additional tax incentives?

j. INTERNATIONAL. Are changes in the R&D budget or budget process required to enable the government to provide effective R&D in support of foreign policy objectives?

k. UNIVERSITIES. What is the probable impact of the Case A and Case B projections on the nation's colleges and universities? Does this impact justify changes in planned levels of R&D budgets? Should it be dealt with as an R&D budget problem or as a matter of federal policy toward higher education?

l. GOVERNMENT LABORATORIES. What is the likely impact of the baseline projections on federal laboratories and other federal R&D installations? Should the trends of the past several years of cutting back in-house government R&D (in Defense and NASA, for example) be continued in future years? What would be the effects on the R&D programs and the quality of the work performed?

m. FACILITIES AND EQUIPMENT. Is there a continuing need for a higher level of funding to enable universities and other R&D institutions to replace and update their facilities and equip-

ment? Should increased funds be allocated for this purpose within agency R&D budgets at the price of constraining agency operating funds for R&D? What are the principal R&D areas where high-cost new facilities are likely to be required in the FY 1979–82 period?

n. WHAT ELSE? Are the questions listed above the real or most important questions? What other questions are equally or more important to consider?

II

Special Topics

Chapter 5

How Should R&D Budget Decisions Be Made?

Last year's AAAS budget report (AAAS-77) told how the system for making R&D budget decisions works, discussed its complexities, and pointed out many of the considerations – often conflicting – that must be taken into account. From its pages, it is hoped, readers could gain a healthy respect for the complexities of the process, see old issues in new lights, and come to a clearer realization that there are at least two sides to every budget problem. But readers would also be entitled to a feeling of frustration. Where does discussion of complexities and considerations lead? Given all the complexities, all the conflicting considerations, how should the system work? What are the real issues in the budget process for R&D that the scientific and technical community and government decision-makers should seek to resolve?

The purpose of this chapter is to address these questions. We shall attempt to sharpen the issues of decision-making on R&D budgets by presenting a concrete hypothesis on how the process should work and how the decisions should be made. Building on the discussions in AAAS-77, we will first summarize some key points that should be taken as "design characteristics" of a system for R&D budget decisions – conditions to be met and conditions to be avoided. Then we will outline the features of a suggested system compatible with these conditions. All this is intended not as final words on the subject ex cathedra, but as a "strawman" to provide a starting point for constructive discussion of the process, rationale, and criteria for budget decisions on R&D. The conditions to be met or avoided are stated as propositions that can be agreed to, modified, added to, or rejected; the strawman system can be redesigned as necessary to correct defects, fill in detail, or meet additional constraints. The hope is that the discipline of a concrete proposal and explicit statements of the conditions to be met will help focus attention on operative issues of R&D budgeting – issues on which one can envisage constructive action, not just endless discussion.

To keep within manageable bounds, our discussion will be mostly in

conceptual rather than institutional terms; we will focus on a *concept* of how the decision system as a whole might operate, not the specific functions of the R&D agencies, OMB, the President, and the Congress. Also, we will have in mind primarily decisions on *how much* should be budgeted for R&D, rather than decisions on how R&D budgets should be allocated to particular projects or performing institutions. This is not meant to downgrade institutional or budget execution questions. Rather, the thought is that such questions can be addressed more fruitfully within the framework of a basic concept of how the system for deciding on the amounts to be budgeted should work. Such a framework is the goal of this chapter.

A. Conditions the System Should Meet

In the paragraphs below, grouped under four headings, are about 20 conditions which the decision system for R&D budgets should meet. We are taking the "system" to include not only the formal processes but also the way the actors in the process behave; thus the conditions represent principles that should govern both the design and the operation of the system. For brevity we shall list them without explanation or discussion; in most cases reference may be made to the discussion of the same points in AAAS–77.

Most of the points in the list will undoubtedly seem obvious. But what is obvious to a research scientist or administrator may be less obvious or even questionable to a budgeteer or a Member of Congress. Conversely, what is taken for granted by government professionals may be news to the toilers in the scientific and technical vineyard. Each of the conditions listed has at times been challenged, opposed, or ignored in the R&D budget process or in talk about it in recent years. Obvious or not, a single list of conditions agreed to by all parties would be a big step forward.

1. Conditions Related to the Governmental Context

(1) The R&D budget decision system must function within the framework of the overall political system. It must recognize that differences of views and viewpoints on R&D do exist, and it must provide for their resolution through the normal processes of persuasion, bargaining, and negotiation within the Executive Branch and in Congress.

(2) Fiscal limitations are necessary and inevitable. There are no blank checks. Annual growth in R&D budgets, or any R&D budget at all, is a privilege, not a right.

(3) Annual budget reviews must be an essential feature of the system; R&D budgeting must fit into the overall annual pattern of the federal budget process. There is always the possibility each year of drastic decisions in the Executive Branch or in Congress.

(4) Periodic, but not necessarily annual, "zero-base" or "sunset" type reviews must be provided in the system.

(5) The system must give visibility to future implications of current budgets and provide the capability for timely control of major commitments.

2. Conditions Related to the Nature of R&D

(1) The system should recognize the legitimacy of federal support of R&D in three different contexts:

Context I: where the goal is to meet defined needs;
Context II: where the goal is to develop technologies, techniques, or concepts, or to demonstrate useful and worthwhile applications of them;
Context III: where the goal is to increase knowledge or understanding as an end in itself.

(2) The system should provide for the consideration of R&D in all three contexts and for the application of policies and criteria that are appropriate in each context, recognizing that R&D may simultaneously serve goals in more than one context or several goals in a single context.

(3) The system must accept the absence, in most cases, of relevant objective criteria for R&D budget decisions and the fact that R&D budget decisions are necessarily judgments in which the values of the decision-makers, persuasion, and bargaining may play a determining role.

(4) The system must avoid the misuse of plausible decision criteria, such as relevance tests, cost-benefit analyses, or marketplace tests of value, in contexts where they are not applicable or their underlying assumptions are not valid.

(5) The R&D budget system must provide the stability of support necessary for continuity of effort and effective performance in R&D work.

3. Conditions Related to Needs of R&D Management

(1) The system must accept and find ways to work around the "lead-time dilemma" (the necessity for making decisions on future phases of R&D programs prior to the completion of current phases).

(2) The R&D budget planning system must seek to anticipate, to the extent feasible, the possible outcomes of R&D; to think through the implications; and to provide on a timely basis for the alternative contingencies of success, failure, or indeterminate results.

(3) The R&D budget system must cope effectively with the problems of scale in R&D; that is, with the enormous size of federal R&D programs. Detailed decision-making should be decentralized to the degree possible; control of policy and major commitments should be exercised by top management.

(4) The R&D budget decision system should rely on and respect the established lines of management responsibility. Review staffs should make recommendations to the responsible line managers, not "second guess" their decisions. The system as a whole should be designed to minimize "single point failures" from a bad decision at any level through suitable provision for reviews, appeals, and public discussion; but clear responsibility for final decisions and for carrying them out should rest with the duly constituted authorities.

(5) The system should provide for timely and effective participation of qualified and interested individuals and groups outside the government in major decisions of R&D budget and program policy. To the extent possible, such participation should take place before official positions have hardened.

4. Conditions Related to R&D Policy

(1) The system for R&D budget decisions must give appropriate consideration to the broader implications of doing or not doing a particular R&D program, or of doing more or less R&D; for example, the implications for the national economy, for national security, and for international cooperation and competition in science and technology.

(2) The system must give special attention to the need to preserve and enhance the nation's capabilities to perform R&D in the future, including the need to maintain effective institutions and facilities for R&D, in and out of government, and a continuing supply of well qualified scientific, technical, and management personnel.

(3) The system should have provision for a quick reaction capability to take prompt advantage of new ideas and possibilities that arise out of phase with normal planning and budgeting cycles.

(4) The system should operate in a fashion to provide incentives and rewards for high quality work and creativity in R&D.

B. A Strawman Suggestion: "Controlled Commitment Budgeting"

Now we shall outline some features of a system concept that might meet, or at least be compatible with, the conditions listed above. Our "strawman" concept could in principle be applied at all levels from top to bottom in the federal R&D enterprise. However, we shall have in mind principally its application at the central management levels of the principal federal R&D agencies, and in their relationships with OMB, the President, and Congress. We are specifically not proposing that it be applied to the totals in the budget for R&D; as explained in AAAS–77, there is no such thing as the federal "R&D Budget" and there are good reasons why there should not be a separate budget for R&D.

To give it a name, we will call our strawman concept "Controlled

Commitment Budgeting" (CCB). Its two principal features are the use of what we will call, inventing further bureaucratic barbarisms, "Baseline Planning Envelopes" (BPE) and "Commitment-Evaluation Cycles" (CEC). As will become evident, neither of these notions is new; in fact, both are now being used to some degree in federal R&D agencies and by OMB. The suggestion is that wider understanding and application of these concepts might make for a more rational and effective budget process and lead to a better consensus on R&D budget decisions. It will also be apparent that the CCB concept and the use of BPE's and CEC's are not limited to R&D budgeting; they permit due recognition of the peculiar aspects of R&D, but they do not demand that R&D receive special or preferred treatment in the budget process.

1. "Baseline Planning Envelopes" (BPE)

The notion of a BPE can be explained simply. The idea is that an overall 5-year or longer budget projection is made of a federal program by the officials responsible for the planning and management of the program. In the cases of interest here, the projections could cover either an agency's R&D program or its total program of which R&D is a part. The envelope starts with the latest approved budgets and, for the succeeding years, shows the amounts estimated to be required for approved program commitments, for expected program extensions and changes, and for an undefined planning "wedge"—an estimate of what might be applied to new programs to be started in future years. The total envelope built up in this way is then divided into elements of two types: major programs or projects that significantly affect the total, and "levels of effort" to be applied in other parts of the program. The major program and project subdivisions of the envelope identify specific program options and decisions which are properly of special concern from a financial standpoint as well as from the standpoints of program need and technical content. The "level of effort" areas cover the portions of the program in which decisions should be made on a policy basis in terms of the level of investment appropriate, rather than in terms of individual decisions on each of a large number of small items. The elements into which the envelope is divided should be tailored to the nature of the program and the needs of management in each case.

In the concept we are suggesting, the central authorities in each R&D agency would correlate a BPE of this type with a baseline substantive program plan. Both the BPE and the substantive plan would be updated at least once a year. Beyond the period covered by approved budgets, both would be regarded only as "baselines," not as firm long-range plans. Long-range planning activities would develop new program options on their own merits; these would be related to, but not constrained in advance by, the BPE. In most cases, new programs would be fitted within the BPE, either by displacing other programs on a priority basis or by filling out the undefined planning "wedge." Impor-

tant, meritorious new program proposals that cannot be accommodated within the BPE could be the basis for a proposal to higher authority to increase the size of the envelope, with the accompanying justification addressing both the merits of the new program and the reasons it cannot fit within the current BPE.

Budget debates could then focus on (i) the fiscal acceptability of the total envelope, (ii) a priority review of the major programs and projects, and (iii) a policy review of the amounts to be budgeted for the principal level-of-effort areas – with full visibility of long-range implications in all three cases. This approach would have the advantage of concentrating the budget decision-processes on policy issues and the general framework of the budget for each agency or program, leaving technical and management details to the proper levels in the responsible agencies. It also has the advantage of permitting issues to be surfaced and debated on a timely basis; if attention is focused on a BPE covering 5 or more years in the future, there can be ample time for participation by the scientific and technical community, Congress, and the public before the curtain has to go down each year on the final throes of the Presidential decisions on the budget for the upcoming fiscal year.

The suggested BPE's must be clearly distinguished from budget ceilings. BPE's are intended as a tool to bring discipline into the planning process and to ensure that future implications of present proposals are laid on the table. But they are not intended as advance constraints on thinking or planning. The use of BPE's outlined above was by agency central management. The same approach could be followed at lower management levels, where a BPE would reflect desirable programs and budgets as seen from that management standpoint, and could be used in budget planning discussions with higher management levels. Similarly, OMB might develop and update its own BPE's for major government programs. These should not be imposed on the agencies as ceilings but should be used to sharpen issues by comparison with the agency BPE's. If the range of differences between OMB and agency BPE's is relatively small, advance budget ceilings of the conventional sort would no longer be required. If the differences are substantial, the BPE's should help OMB decide on the ceilings to be set and help the agencies assess and cope with their impact.

2. *"Commitment-Evaluation Cycles" (CEC)*

In the previous section we referred to "commitments." In the federal budget process, are there any real commitments? With annual reviews, especially zero-base reviews, nothing is sacred. A new administration or an angry Congress can cancel programs right and left. The toughest problem in designing an R&D budget decision-system is to meet simultaneously the two constraints: (i) the necessity of preserving the right of the President and Congress to change their minds each year

in the annual budget review, and (ii) the need for long-term commitments to get R&D work done.

Historically, one way R&D has resolved, or at least survived, this contradiction has been through the device of long-term contracts funded in annual increments. Industry and universities have come to accept contracts embodying long-term commitments but containing clauses limiting the government's financial liability to the funds actually appropriated by Congress each year (plus termination costs in some cases). Beyond such formal arrangements there are many other implied long-range commitments in R&D, such as policy statements that certain work will be continued, informal understandings that renewals will be recommended and probably approved, and the de facto commitments that exist in situations where the government's needs or half-finished work make it impossible for the government to pull out.

The second feature of the "controlled commitment" concept for R&D budget decisions proposes an explicit definition of the commitment in each case, combined with a plan for evaluation and decisions on further commitments. The idea is that for every major program or "level of effort" area, the responsible managers would lay out a "Commitment-Evaluation Cycle" (CEC) in a statement spelling out the nature and extent of the government's initial (or current) commitment, taking "commitment" to mean the current expectations and intentions of management. Each CEC statement would specify the work which management intends to be accomplished, in terms of results to be achieved, phases of the project to be completed, or amount of effort to be applied – whatever is the most appropriate basis for evaluation in the particular case. The CEC statement would also include a plan and schedule, indicating the period of work covered by the commitment, the period during which the work or its results will be reviewed and evaluated, and the time at which the decision will be made on continuing, terminating, or redirecting the program. Decisions to continue or redirect would require a new CEC statement and another round in the cycle would begin.

With an explicit CEC document for each major program or "level of effort" area, all concerned – managers, reviewers, Congress, and those performing the work – would have a clear common understanding of the nature and limits of R&D commitments. The specification in advance of review, evaluation, and decision periods could meet the concerns that have given impetus to zero-base budgeting in the Executive Branch and sunset legislation in the Congress. At the same time, if the commitment periods are reasonable in relation to the needs of the R&D work, the R&D performers should also benefit from less harassment in annual budget reviews by agencies, OMB, and Congress. They will know in advance when they will be judged, and they will have a pretty good idea of the basis of the evaluation and future decisions. The net effect could be clearer and longer-term commitments than they now may have.

The crux of successful application of the CEC principle will be the realism and reasonableness of the cycle laid down in each case, particularly how it deals with the lead-time dilemma. It must avoid placing either the program and its advocates, on the one side, or the reviewers and management on the other, in a "Catch 22" situation. If the cycle calls for reviews and evaluation prematurely, and makes them a condition precedent for permitting the project to proceed, then the project can't win. This kind of situation could arise in applications-oriented R&D where test results in the R&D program are needed to evaluate whether the proposed application is feasible and worthwhile. On the other hand, if R&D enthusiasts insist that the continuing nature of R&D means that there is never a point in the cycle where a meaningful evaluation can be made, then budget reviewers and other skeptics can rightly feel they have been had.

To meet this problem, full recognition must be given to lead-time problems in setting the CEC for a particular program. The key is to make the initial commitment long-term enough to cover both the time a meaningful segment of work will take and, in order to preserve the option for continuing without interruption, the time needed for the review, evaluation, and decision processes, including any extra time needed to get in phase with the next budget cycle. The decision processes can be assisted and perhaps expedited if the CEC statement can anticipate the bases on which the R&D work should be evaluated and the range of possible outcomes—success, failure, or indeterminate results. To the extent that managers and reviewers can think through in advance the implications of each outcome and the decisions they would then face, it should be possible to minimize the length and uncertainties of the evaluation and decision period.

Like the BPE's, the CEC concept could be applied at all levels within R&D programs and organizations. At program management levels the CEC could provide the framework for a meaningful "management by objectives" (MBO) system. At policy planning levels, the CEC's for major projects could be coupled with the BPE to provide the basis for controlling major commitments within the desired fiscal envelope.

3. Criteria for Budget Decisions

Let us conclude this sketch of a suggested concept for R&D budgeting by considering briefly how "Controlled Commitment Budgeting" might be applied to R&D in each of the three contexts identified earlier: R&D to meet defined needs, R&D to find and develop useful applications, and R&D to increase knowledge as an end in itself. The decision criteria to be applied in each case are not predetermined by the CCB concept nor by the conditions laid down earlier; the criteria are themselves policy issues to be debated and resolved in the continuous iterative process CCB envisages. The following suggestions illustrate approaches that could be taken.

In our Context I (R&D to meet defined needs), the focus in budget decisions should be on the government's overall campaign plan to meet the needs in question. A BPE could be laid out covering all R&D and non-R&D elements of the plan, with CEC's established for each element. Each R&D element would be judged on the basis of its expected contribution to meeting the defined need; trade-offs within the BPE would be in terms of the relative costs and expected contributions of both R&D and non-R&D elements. Judgments on the size of the total envelope would be based on the urgency of the need and the cost of effective measures to meet it. Trade-offs necessary to meet overall fiscal constraints should be made with similar total envelopes for meeting related needs, not with other R&D.

In Context II (R&D on technologies, techniques, or concepts to find and develop useful and worthwhile applications), the amounts budgeted for R&D should be regarded as part of an overall national investment in future options. General applied research, technology development, and experimental applications should be recognized as comprising an essential investment category. Without effective R&D programs in this category, there is no way to realize the potential benefits of basic research or to develop new options for R&D programs directed at specific needs. BPE's for R&D in Context II should be based on policy judgments on the likelihood of worthwhile results and on the appropriate total annual level of investment in work in Context II. Criteria requiring a direct relation to specific needs, appropriate in Context I, should not be forced on R&D in Context II. The CEC's should be carefully drawn up, however, to identify as clearly as possible the expected beneficial applications and the implications of success, failure, or indeterminate results. This should facilitate prompt realization of the benefits of success and help avoid overinvestment in applications that can be shown in advance to be impractical or uneconomical.

For R&D in Context III (where the goal is to increase knowledge or understanding as an end in itself), budget decisions involve acts of faith – the acceptance of knowledge and understanding as values in their own right or the conviction that relevancies will ultimately emerge to justify in Context II R&D begun in Context III. BPE's for basic research should be established on a policy-judgment basis, and proposals for higher or lower levels should be debated in terms of the opportunities and losses each would imply. The final decision will always be a political judgment, arrived at through the normal processes of advocacy, opposition, bargaining, and decision within the Executive Branch and in Congress.

C. Questions and Issues

The basic question posed in this chapter is whether or to what extent the scientific and technical community and the responsible offi-

cials of government can agree on the bases on which R&D budget decisions should be made. What are the points on which agreement can be reached? On what points must R&D advocates and government officials agree to disagree?

Using the suggestions outlined in this chapter as a focus, we may ask the following more specific questions, among many others:

(1) Are the points listed in Section A valid as conditions which the R&D budget decision system should meet? Are they acceptable to the scientific and technical communities? To responsible managers and budget officials in the Executive Branch? To Congress? What other conditions are seen as necessary from each standpoint? What changes in current processes and practices are required to meet the necessary conditions?

(2) What are the pros and cons of "Controlled Commitment Budgeting," the "straw man" system outlined in Section B? Is it practical? Would it unduly slant budget decisions in one direction or another? Would it help meet the principal current concerns with the R&D budget process of the scientific and technical community? Of executive agencies? OMB? Congress? Would it be compatible with the new emphasis on zero-base budgeting? What additional features should be incorporated in the system for making R&D budget decisions?

(3) Is the approach to decision criteria for R&D budgets outlined in Section B–3 valid? What alternatives should be considered? Can acceptable and more specific criteria be laid down? Can the range in which budgeting judgments have to be made in "level of effort" areas, like basic research and technology development, be narrowed by devising criteria for both lower and upper limits on the appropriate annual investment levels?

(4) What significant points have been missed in the analysis in this chapter? What other answers can be advanced to the fundamental question: How should R&D budget decisions be made?

Chapter 6

The Congressional Role in R&D Budgeting

The aim of this chapter is to present a fairly full account of how Congress considers and acts on R&D budgets and to identify some questions and issues that deserve consideration by those in and out of government concerned with the making of budget decisions on R&D. The following section, by Herbert Roback, describes the Congressional budget process against the backdrop of the political environment in which legislative decisions are made. It explains how Congressional attitudes toward R&D are shaped by institutional and political necessities, the workings of the dual committee system for program authorization and funding, the new discipline imposed by the Congressional Budget and Impoundment Control Act of 1974, and the dimensions and role of the Congressional staff bureaucracy, including support agencies. At the end of the chapter we summarize and list for discussion and further study some questions and issues in the legislative processes that affect Congressional consideration of R&D budgets.

Congress and R&D Budgeting

By Herbert Roback

A. Congress as an Institution

1. A Collegial Body

It will help our understanding of the Congressional budget process to keep in mind that Congress is a collegial body, not a bureaucratic hierarchy. It is an assemblage of elected members, each holding himself accountable to a voting constituency rather than to a superior in command. Leadership in Congress is exercised through committee chair-

men and high-ranking members, and a loose political organization for each house which includes (with some variations) presiding officer, majority and minority leader, whips and caucus, steering and policy committees. Congressional leaders exercise considerable authority and influence but cannot, by themselves, make controlling decisions on legislation. Decisions in committee or on the floor of each house are made by majority vote or unanimous consent. A great deal of bargaining, negotiating, trading, and compromising attends major legislative decisions because support must be mobilized and a diversity of political, regional, economic and other interests must be accommodated.

The Executive Branch, in contrast to the Congress, is more or less a hierarchy. Most departments and agencies have a single head and established lines of authority from the top down. The President, sitting at the apex, serves as the chief executive and general manager, with the constitutional obligation to see that the laws are faithfully executed. There is bargaining and trading in executive decisions also, but a single authority signs off. The budget that the President sends to Congress each year is distinctively his own. It embodies his fiscal goals, program initiatives, and final decisions on issues put before him by his Budget Director. The budget that Congress enacts into law is the product of many hands in many Congressional places. And it is not a single enactment but a whole parcel of statutes developed through an intricate network of committee and floor procedures which make up the Congressional budget process.

2. *A Bicameral System*

The President's budget works its way through a Congressional system that is not only collegial but bicameral—composed of two houses. The House of Representatives and the Senate are relatively self-contained institutions with similarities and differences in constitutional authority, composition, representational base, committee organization, and style of work. Apart from a few joint committees or joint hearings of separate committees, the main connection between the two houses is the conference committee, a temporary ad hoc arrangement to resolve differences in bills passed by each house. Differences are not always resolved, or one house may pass a bill and not the other, in which cases the legislation dies, perhaps to be resurrected in another Congress.

In budget and fiscal matters, the House of Representatives is preeminent because all bills to raise revenues and appropriate funds originate there. For yearly appropriations, the Senate typically serves in a review or appeal capacity, hearing "reclamas" from agency administrators who suffer House budget cuts. Frequently the Senate restores or increases funds, and just as frequently differences are reconciled in conference by being split down the middle. If agreement is not reached before the fiscal year ends, expedient measures are taken in the form of "continuing resolutions" to permit funding at the previous year's level

until the regular appropriation bill is enacted. Appropriations have a higher order of necessity than other bills because the wheels of government must continue to spin.

3. A Political Environment

The Congressional environment is more political than that of the other branches of government. For one thing, the organization and operations of Congress are built around the two-party system. The Democrats, being in the majority, "control" the House and the Senate. All committee chairmen, with rare exception, are Democrats. Each committee, with a few special exceptions, has more Democrats than Republicans. Scheduling of bills is under Democratic control. However, the Republican (minority) leadership is consulted or kept advised, and minority members have recognized rights and privileges in committee participation, calling witnesses to hearings, staffing, office space, floor seating, expression of views in reports, and time allowed for floor debates.

Majority control of Congress for purposes of internal procedure and administration does not mean that the majority party prevails in all decisions. There are liberals and conservatives in both parties. Coalitions of members from both parties form and reform around specific issues. The thinner the party majority, of course, the more difficult it is for the party majority to prevail on controversial issues. The member will vote with his party when he can, and in most cases he does, because he runs for office under the party banner, sharing more or less its political outlook and program commitments and accepting its moral and financial support.

Members inclined to defect may be pressured strongly by colleagues, the leadership, or the White House, to get a winning margin in close contests. The fact remains, however, that the political needs of the individual member take precedence. He weighs his actions in Congress—the committee assignments he seeks, the bills he sponsors, the speeches he makes, the votes he casts—in terms of the political consequences to him. His continuance in office depends on success in recurring elections. In the Congressional environment, holding office and running for office are synonymous. The whole House and one-third of the Senate are up for election every 2 years.

Success in election means paying careful attention to constituency attitudes and demands. Bread-and-butter issues come first. There are times, of course, when dictates of conscience and demands of constituencies are in conflict. In compelling circumstances members may decide to let their consciences be their guide and cast their votes for what they perceive to be the higher national interest. They may take satisfaction in recalling Edmund Burke's rebuke to his Bristol constituency that he was elected for a more important purpose than simply to do their bidding.

4. Attitudes Toward R&D

Fortunately for them, most members of Congress have little trouble in identifying constituency demands with the best interests of the nation. They manage to frame their concepts of military strategy or of scientific development to favor particular weapon systems or technical facilities within their States or districts. Few are interested in abstract issues such as science policy or R&D in general. They look at agency programs and budgets and assess their worth in terms of jobs and payrolls and other benefits. Those who have among their constituents universities with large federal grants, or technical centers, or high-technology contractors, usually can be counted upon to be strong advocates of R&D programs, particularly if they can be assured that some of the benefits will accrue to their part of the country.

Congressional attitudes toward R&D are shaped by changing circumstances as well as constituency concerns. Energy shortages, in fact or in prospect, bring forth a heavy increase in funds for energy R&D. When world tensions rise, large sums for military R&D are readily sanctioned; and when tensions abate, military R&D become vulnerable to budget cutting as a way of "nipping in the bud" expensive, new weapon systems. Usually it is the "D" rather than the "R" which suffers, for developmental hardware is the costly part. In other circumstances, R&D funds may be voted for protracted periods as a way of deferring hard decisions on controversial and still more costly production programs.

On the whole, R&D fares rather well in Congress. There is more stability and continuity in R&D program authorization and funding than the uncertainties of the legislative process might seem to suggest. Members who sit on committees and subcommittees dealing with major R&D programs, by dint of hard work and long service become well-versed in these programs and highly effective in getting sustained Congressional support. Those who serve as chairmen of committees and subcommittees having jurisdiction over R&D programs not infrequently emerge in strong leadership roles and command national attention as authoritative spokesmen in Congress for their areas of legislative responsibility. In health, energy, environment, space, national defense, maritime affairs and other areas of R&D interest, outstanding members of Congress have, through the years, left the imprint of their personalities and lasting contributions in legislative achievement.

B. Committees and Budget Cycles

In the Executive Branch, the destinies of departments and agencies are determined by programs and money. Consequently, the committees of Congress are of critical importance in that they develop the legislation to authorize programs and provide funds, doing so by separate sets of

laws. This means that for program justification and funding, administrators in key program areas have to appear each year before four committees, two in each house, usually acting through subcommittees. If agency programs cut across committee jurisdictions, additional committees will be involved in the authorization phase.

Both sets of committees—authorization and funding—now must work within funding limits and scheduling disciplines developed by another set of committees—Committees on the Budget in the House and Senate. The result, as outlined in last year's report and appendix (AAAS-77), is three cycles of Congressional budget activity which go on each year, overlapping in time and interactive in effect. The logical sequence is that budget (target) ceilings are set first, program authorizations are made next, and specific appropriations follow last.

Historically, the sequence is the reverse. Appropriations by law, a constitutional requirement, are as old as the federal government. Authorizations by law, as a specific prerequisite to appropriations, came along later, and the budget ceilings are of recent vintage. We will sort out these procedural distinctions in the paragraphs that follow.

1. Appropriating Funds

The Constitution, in Article I, section 9, clause 7, solemnly proclaims: "No money shall be drawn from the Treasury, but in consequence of appropriations made by law. . . ." This very important but drudging legislative task falls in the first instance to the Committees on Appropriations in the House and Senate. Each committee works through a dozen or more subcommittees (13 at present). To each subcommittee is assigned a piece of the budget submitted each year by the President. The chairman of the full committee determines how many subcommittees there will be and the jurisdiction they will have. This jurisdiction is defined in terms of agencies and functions and is roughly parallel in the House and Senate.

The subcommittee division of labor has in it more custom and expediency than logic. It was customary, for example, to have a subcommittee handling appropriations for "independent offices." That subcommittee now handles appropriations for the National Science Foundation, National Aeronautics and Space Administration, Department of Housing and Urban Development, Veterans' Administration, and various other executive agencies, boards, commissions, and corporations. The appropriations for all agencies or functions assigned to one subcommittee are incorporated into a single bill. With a dozen or more subcommittees at work, and supplemental or deficiency bills added in, 15 or more appropriation laws will be enacted in each session of Congress. This mosaic covers the federal establishment, except that certain agencies and programs are privileged to have permanent or mandatory appropriations or access to other sources of funding.

Each subcommittee works within its own jurisdictional bailiwick. It

schedules hearings, calls government administrators to explain and defend their budget requests, and on a controversial subject will listen to testimony from outside witnesses. For government administrators, the appropriations hearings can be a very difficult or disappointing experience. Questions may be thrown at them which they are unable to answer, or they may spend nights preparing themselves to answer questions which never are asked. Pressed for time with so many agencies' budgets to review, members may keep busy administrators sitting around for hours or days and then dispose of their presentations in minutes.

Traditionally, hearings of the subcommittees and bill mark-up sessions were closed to the public. Hearings were printed subsequently in bulky volumes, often too late for interested members to peruse or digest their contents. And those hearings in which classified data were presented would be printed with so many deletions as to make much of the testimony useless to the outside reader. Changing sentiment in Congress in favor of open hearings and open mark-up sessions have persuaded the subcommittees on appropriations to follow the example of other committees, although closed sessions still prevail in many cases.

When hearings are finished, subcommittee members decide whether to accept, modify, or reject specific line-item requests. Controversial items may be deleted or expensive programs cut back, particularly when there are indications of management problems or deficiencies in performance. On occasion, items will rate increases, to emphasize the importance the subcommittee attaches to them. However, total budget requests rarely are met in full. To comply with agency requests makes the subcommittee appear as rubber-stamping the executive and failing to exercise critical judgment. The House subcommittees also may cut more heavily than usual to gain political credit for reducing expenditures, anticipating that budget cuts will be restored in the Senate. The subcommittee bills are reviewed and approved in the full committee, not all at one time but as mark-ups are completed. Changes by the full committee are relatively few and confined to big-dollar items or those which are politically sensitive.

After the full committee orders the bills reported, they are scheduled for floor action in consultation with the leadership. Since appropriation bills in the House are "privileged," they may be brought to the floor without going through the Committee on Rules, unlike other legislation. However, when technical provisions in an appropriation bill may give rise to points of order, the chairman appears before the Committee on Rules to seek a rule waiving points of order. An example would be an appropriation bill appearing late in the session and lacking the prior authorization required by the rules. On the floor, amendments are permitted but few prevail. The committee and subcommittee chairmen successfully fend off most efforts to alter their handiwork. Their arguments, backed up by the detailed knowledge in possession of the subcommittee, carry great weight with their colleagues.

The dispersion of government funding decisions among 13 subcommittees in each house and 14 or 15 appropriation bills each year, makes it difficult to match funding with policy or program objectives which cut across agencies. Several years ago, the House Committee on Appropriations tried to demonstrate the adaptability of its subcommittee system to concerted and timely action in urgent circumstances when the Special Energy Research and Development Appropriation Act for FY 1975 was enacted. Six appropriations subcommittees worked cooperatively to extract from the budgets of a dozen different departments, bureaus, agencies and offices the estimates for energy R&D and put them together in a single bill, conferring $2.2 billion in new budget authority for energy R&D, $66 million more than requested by the executive. The rationale was to move quickly so that the R&D monies would be available for obligation at the beginning of the new fiscal year, and also, as Chairman Mahon said, "to gain an overview of the thrust of the Federal energy research and development effort." The effort was commendable, but given the customary patterns of subcommittee behavior, it is not likely to be repeated short of a dire emergency.

2. *Authorizing Programs*

The Constitution mandates appropriations by law; it says nothing about prior authorizations. The requirement that an authorization precede an appropriation is a parliamentary device invented more than 100 years ago to keep appropriation bills from being saddled with legislative "riders," which slowed their movement through the legislative system. Thus, there was set up a dual legislative process. Authorization was one enactment, funding another and separate enactment. To maintain the sanctity of this procedural distinction, the general concept is that legislative committees should not appropriate, and appropriations committees should not legislate. In practice, the distinction is not fully maintained. Legislative committees can force appropriations through backdoor methods, and appropriation bills frequently carry legislative riders.

The traditional practice of legislative committees, in creating a new agency or program, was to satisfy the prior authorization requirement by conventional language in a bill along this line: "There are hereby authorized to be appropriated such sums as may be necessary and appropriate to carry out the provisions and purposes of this act." It was, in other words, a one-shot general authorization with permanent effect. Thereafter, the federal agency affected would come to the appropriations committees for its yearly funds, without the need for additional authorizations by the legislative committees.

In the 1950's and early 1960's, as monumental scientific and engineering developments proceeded apace in nuclear, space, and weapons fields, the legislative committees in these technical areas moved to enhance their power and influence by obtaining statutory sanction for authorizations on a recurrent *yearly* basis. Thus the affected federal

agencies would have to appear each year before the legislative as well as the appropriations committees. Today, government agencies and programs which account for the bulk of R&D expenditures are subject to yearly authorizations. These agencies include ERDA (as successor to the Atomic Energy Commission), NASA, NSF, and the Department of Defense (for given program categories, including research, development, test, and evaluation).

a. Atomic Energy Commission

Legislative moves toward yearly authorization were taken in successive and sometimes erratic steps. For example, the Joint Committee on Atomic Energy (JCAE), when it considered basic amendments in 1954 to the Atomic Energy Act of 1946, decided to qualify the general authorization which had been granted for appropriations to the Atomic Energy Commission by requiring *yearly* authorization for the acquisition, construction, or expansion of plants and facilities. In 1957, the definition of "facility" was expanded to include civil reactor programs for the production of electric power; and in 1963, the AEC's entire budget was made subject to yearly authorization. Now that the AEC has been broken up, and the JCAE stripped of its legislative power, yearly authorizations will be made separately for military and non-military nuclear energy R&D, the Nuclear Regulatory Commission, export of nuclear technology, and possibly other components. Four or five committees, and as many or more subcommittees, in each house, will be involved in the yearly authorization of nuclear programs.

b. National Aeronautics and Space Administration

The National Aeronautics and Space Act, which became law in 1958, carried the conventional language for a general authorization, except that purchases of real property and items of a capital nature (such as the acquisition, construction or expansion of plants and facilities) exceeding $250,000 in amount would require yearly authorization. In 1959, after some preliminary moves through appropriation riders, a NASA authorization act specified that the whole NASA budget henceforth would be authorized annually by the legislative committees on space before being funded by the appropriations committees. The initiative in this respect was taken by Lyndon B. Johnson, Senate Majority Leader, who had served as chairman of the select committee in the Senate which helped to develop the basic legislation creating NASA.

c. Department of Defense

For many years, construction at military installations had been authorized on a yearly basis, but armaments, large and small, came under general authorization umbrellas for the military services. By 1959, sentiment had crystallized in the Senate Committee on Armed Services for yearly authorization of design, development, and procurement of

aircraft and missiles. As first enacted, the requirement was limited to "procurement" of aircraft, missiles, and naval vessels; but after a controversy between the House Armed Services Committee and Secretary of Defense Robert S. McNamara over funding for a new bomber development (RS–70), coverage was extended to "research, development, test or evaluation" (RDT&E) in 1963. Subsequent enactments expanded the requirement, so that practically the whole range of weaponry and manning (force strength) now is authorized year by year.

d. National Science Foundation

Compared to the other agencies with major R&D expenditures, NSF came to its annual authorization requirement rather late in the game. When NSF was created in 1950, its enabling legislation provided, instead of the conventional language of a general authorization, a specific sum for each fiscal year. The modest sum of $500,000 was provided for fiscal year 1951, and $15 million for each fiscal year thereafter. A 1953 amendment to the National Science Foundation Act deleted the specific figures and reverted to the general appropriation language – "such sums as may be necessary to carry out the provisions of this act." Then, 15 years later, when the 1968 amendments revamped the act and allowed NSF to support applied research and research in the social sciences, the specific amount of $535 million was authorized for fiscal year 1969; but for fiscal year 1970 and thereafter, "only such sums as the Congress may hereafter authorize by law." Thus the NSF came around to the annual authorization requirement. The Senate Committee on Labor and Public Welfare, in reporting the legislation, explained why: NSF appropriations had increased 2000-fold – from $225,000 in 1951 to $495 million in 1968, and there had been "no thorough review" of the NSF authorization since the original enactment.

3. The Double Look

The committees of authorization receive the same justification books which the agencies prepare for the Committees on Appropriations, and they may ask for additional information in a different format. The subcommittee and committee processes are pretty much the same as with appropriations. Hearings are held, witnesses are called from the agencies, bills are marked up by the subcommittees, approved by the full committees, and brought to the floor of each house for passage and then for reconciliation of differences. Since authorization bills technically are not appropriations, the Senate need not wait upon the House before it reports out an authorization bill. The hearings of the authorizing committees, except in classified matters, generally are open, as are the mark-up sessions. The authorizing committees, in important or controversial policy areas, also take testimony from persons outside the government.

In both sets of committees – authorization and appropriation – both the yearly bills and the accompanying reports offer recurring opportun-

ities to admonish, instruct, restrict, and otherwise qualify the administrator's initiative and independence in spending funds. What is carried in the bill has legal force and effect. What is carried in the report may be an elaboration of committee intent or expectation, without the same legal effect but ignored by administrators at peril to their programs. Some flexibility also is accorded administrators by committee permission to reprogram funds within appropriation accounts, and by statutory provisions for discretionary use or transfer of funds within prescribed limits.

To insure that favored programs get proper attention, the authorization and appropriation bills both will earmark sums for specific programs. Picking a statute at random, we may note the NSF *authorization* for fiscal year 1974 carried $91 million for Research Applied to National Needs (RANN), but specified that not less than $24 million of that sum was authorized for energy research and technology programs, including solar, geothermal, and other nonconventional energy sources; and not less than $8 million for earthquake engineering programs. The NSF *appropriation* for the same fiscal year specified that not more than $72 million was to be available for RANN (in contrast to the $91 million authorized). The same year in a supplemental appropriation act, an additional $3,100,000 was allowed for RANN.

The authorization and appropriation acts for any given year also carry miscellaneous provisions which reflect issues of contemporary interest or concern. For example, during the years of campus unrest and violence, enactments for NSF typically contained provisions barring the payment of government funds for employing or assisting students engaged in acts of violence, property seizure, or willful disregard of lawful regulations. Such provisions were carried in both the aforementioned 1974 acts. The NSF authorization act for that year also barred funds "to conduct or include research in the United States or abroad on a human fetus which is outside the womb of its mother and which has a beating heart."

The NASA authorization acts, reflecting a perennial concern in the Congress that R&D funds be widely distributed, have carried for many years, this section:

> It is the sense of the Congress that it is in the national interest that consideration be given to geographic distribution of Federal research funds whenever feasible, and that the National Aeronautics and Space Administration should explore ways and means of distributing those research and development funds whenever feasible.

To ascertain the sense and sentiment of Congress on various policy matters, including R&D, one would have to comb the numerous authorization and appropriation statutes, year by year. Such yearly enactments provide not only opportunities to express general sentiments but to amend basic legislation. Thus, the NASA authorization act for fiscal year 1976 added a new title IV to the National Aeronautics and Space

Act on upper-atmospheric research. It authorized, in cooperation with other federal agencies, "a program of research, technology, monitoring, and other appropriate activities directed to understand the physics and chemistry of the upper atmosphere."

The double look by committees of authorization and appropriation in each house – making it a four-way committee process – gives rise to much complaint in the Executive Branch about the waste of time in so many appearances on the same subject. It also creates tensions between the two sets of committees, not only because of scheduling problems but also because of occasional sharp differences in policy and funding assessments. The authorizing committees determine program boundaries and set dollar ceilings. The Committees on Appropriations can only fund programs which have been authorized and may not exceed the authorized dollar ceiling, although they may and usually do appropriate less, or in some instances may appropriate nothing at all and turn a program authorization into a dead letter.

Tensions between committees of authorization and appropriation arise in part from differences in attitude. Traditionally those who sit on the appropriation committees are more conscious of the dollars and take a hard-nosed approach to agency justifications for new or added expenditures. As students of the Congress have observed, members of the Committees on Appropriations tend to be conservative and senior in status. New members rarely have access to coveted places on these committees. In the House this barrier has been lowered somewhat by a Democratic Caucus rule which limits senior members to service on two appropriations subcommittees, and by another rule which requires the Caucus to select the subcommittee chairmen.

The authorizing committees are the committees of advocacy. Not being responsible for the actual dollar outlays, they tend to press for new and expanded programs. Through their subcommittee organization, they can usually give more time and attention to yearly program reviews than the appropriation subcommittees. For example, the House and Senate Armed Services Committees each has a subcommittee exclusively concerned with the yearly authorization of RDT&E in the Department of Defense. In the Committees on Appropriations, a single subcommittee must cover a whole range of defense matters. Similarly, the House and Senate committees authorizing the NASA budget give it a much more extensive annual review than do the appropriations subcommittees, where assorted agencies compete for time and attention.

In earlier days, when many legislative committees actually made appropriations, they were criticized for porkbarrel politics and failure to be guided by economy in government expenditures. Today, the separation of authorizing and appropriating functions, apart from the duplication (or quadruplication) in hearings and bill processing, serves as an internal check and balance. New programs are advanced in one set of committees, dollars are husbanded in another. The conjoint involvement makes for a broader base of Congressional knowledge and interest

in specific programs. The destinies of agencies or programs do not hang so heavily on the whim, caprice or penny-pinching disposition of the chairman of a particular appropriations subcommittee. Agencies such as the National Oceanographic and Atmospheric Administration, which are not subject to yearly authorization requirements for all their programs, could be worse off than those which must justify themselves each year before two sets of congressional committees in each house.

4. Congressional Budget Ceilings

a. An Earlier Experiment

The Congressional Budget and Impoundment Control Act of 1974 set new disciplines for authorization and funding and for relating total expenditures to revenues. It was a new and refined version of an idea carried in the Legislative Reorganization Act of 1946. The idea was that the committees in each house dealing with revenues and appropriations would sit together each year as a Joint Committee on the Budget, consider the President's budget recommendations, and report to their respective bodies a *legislative budget ceiling* for the ensuing fiscal year. The Joint Committee report would estimate total federal receipts and expenditures and recommend the maximum amount to be appropriated, including a reserve for deficiencies. If estimated receipts exceeded estimated expenditures, the report was to contain recommendations on reducing the public debt. The report would be accompanied by a concurrent resolution fixing the appropriation ceiling. The Joint Committee report was due on February 15 of each year.

To Senator Arthur Vandenberg, the legislative budget was "an epochal innovation, pregnant with hope for the long-suffering American taxpayer." It proved to be abortive. The budget resolution for 1947 fell through because of disagreement, and in 1948 the Congress approved a ceiling but refused to abide by it. Since the Joint Committee, an unwieldy composite of four committees numbering 104 members, had no special staff and only a month to review the massive Presidential budget and make its own recommendations, it was criticized for rough guessing and hasty judgments made in closed sessions. In 1949 the Congress extended the reporting date to May 1, but no resolution came forth, and the idea of the legislative budget was abandoned.

Many ideas for budgetary reform surfaced in the ensuing 20 years, but not until 1974 did the Congress refashion them into comprehensive legislation. The precipitating factors were contests between the Congress and the Nixon administration over spending ceilings and Presidential impounding of funds, and the virtual breakdown of the appropriating functions. Every year, appropriation bills were late, spilling over into the next fiscal year. The blame, in large part, was put on the annual authorization requirement. The Committees on Appropriations, waiting for the authorizing bills to pass first, came in late with their own,

and in numerous instances they had to use the expedient of the continuing resolution.

b. New Authorization Deadline

The Congressional Budget and Impoundment Control Act of 1974 put a deadline on authorizations. Bills authorizing new budget authority for a fiscal year (which begins October 1 under the new legislation) must be reported to the House and Senate by May 15 or risk being thrown out on points of order. Only in emergency situations, and by approval of each house, can the May 15 deadline be extended for reports of authorizing committees. A severe strain is imposed on these committees to complete their hearings and present their legislative bills. The committees and subcommittees now start earlier in the session and move at a forced pace, often in continuous daily sessions, to complete their work.

Recognizing that this deadline was not altogether reasonable for the reporting of authorization bills, those who drafted the 1974 legislation entered a provision that agencies which require authorizations must submit their requests to the Congress by May 15 of the year preceding the fiscal year to which the authorization would apply. In other words, an authorizing committee could begin its work, if it so desired, a year before its report was due. This extra time is not an unmixed blessing, since program requirements and circumstances may change significantly, and the effectiveness of the committee's yearly program review and recommendations can be greatly diminished by the time the Committees on Appropriations get around to their own reviews.

c. Rein on Appropriations

The disciplines imposed by the 1974 act upon the Committees on Appropriations are briefly these:

(1) No appropriation bill can be reported before the Congress completes action on the first concurrent resolution, which sets a target ceiling for new budget authority and outlays during the coming fiscal year, and estimates for each major category of budget functions (17 in number) using the same classification as the Presidential budget. That resolution must be reported in each house by April 15 and passed by the Congress on or before May 15, allowing a month for floor action and conference to resolve differences.

(2) The conferees are required in their joint report to make estimated allocations of the total new budget authority and outlays among the committees having jurisdiction over new budget authority. The Committees on Appropriations primarily are affected, although certain other committees can commit the government to expenditures, as in case of social security payments and other mandatory expenditures. The House and

Senate committees in turn subdivide the allocation among the subcommittees having jurisdiction.

(3) Before reporting its first regular appropriation bill, the House Committee on Appropriations must complete subcommittee mark-up and full committee action on all regular appropriation bills and present to the House a summary report, showing how the committee's recommendations compare with the levels designated in the concurrent resolution.

(4) The appropriations committees report their bills between May 15 and the early part of September (the seventh day after Labor Day). The reports accompanying such bills must (i) show how the proposed new budget authority compares with that set forth in the concurrent resolution; (ii) make projections for each of the next 5 fiscal years of the outlays to result from the new budget authority; and (iii) show what part of new budget and outlays provide financial assistance to State and local governments. These reports are to be prepared in consultation with the Congressional Budget Office, established by the act. That office keeps its own score and issues "score-keeping reports" to indicate whether committees, in preparing their bills, are staying within prescribed ceilings and allocations.

(5) By September 15 the Congress must pass a second concurrent resolution, reaffirming or revising the figures in the first one; and if new figures are set, the resolution must direct the Committees on Appropriations and other committees involved to make the necessary conforming changes in bills.

(6) Directions to committees, when carried in the resolution, lead to the passage of another resolution (or bill) of reconciliation, which must be completed by September 25. Congress may not adjourn until action on the second concurrent resolution or the reconciliation process is completed.

(7) Once the second concurrent resolution and reconciliation action (if required) are disposed of, additional appropriation bills are not in order if they would cause the level of new budget authority or outlay to be exceeded. This restriction would apply mainly to supplemental or deficiency bills or continuing resolutions.

The procedure as described above has been simplified to emphasize the impact on the Committees on Appropriations. In fact, the first and second concurrent resolutions not only prescribe ceilings on appropriations and estimates by functional categories, but tie the new budget authority and outlays to federal revenues and the public debt. Thus the budget resolution makes explicit and visible the deficit between income and outgo and may carry recommendations for increasing or decreasing federal revenues and adjusting the statutory limit on the public debt. Decisions on ceilings affect the general economy; allocations among budget categories allow the Congress to make comparative judgments and shift priorities for expenditures.

The first and second concurrent resolutions do not necessarily wed the Congress to its own budget totals for the coming fiscal year, as shown by the changes made in the second concurrent resolution passed in September 1976 for fiscal year 1977. The sharp decline in economic activities, the change of administration, and new proposals by President Carter for stimulating economic recovery led the Congress in February 1977 to pass a *third* concurrent resolution for fiscal year 1977, revising the second budget resolution to accommodate the President's proposals.

d. Preparatory Actions

Before the first budget resolution is reported by April 15, the Committee on the Budget in each house will have taken certain preparatory actions. The process starts when the President submits his preliminary budget estimates, required by November 10 of the preceding year. These estimates show proposed new budget authority and outlays for the next fiscal year on the assumption that no new programs are involved. The Joint Economic Committee has the job of evaluating this package and submitting its views to the Committees on the Budget by December 31. The President's regular budget is submitted within 15 days after the January session of Congress begins. Hearings are held by the Committees on the Budget and testimony taken from members of Congress; executive agencies; and outside groups on fiscal and economic policies, agency programs, and other matters deemed pertinent.

By March 15 of each year, the Committees on the Budget receive the views and estimates of all standing committees as to the total amounts of new budget authority and outlays anticipated as a result of the legislation they will bring forth for the new fiscal year. Additionally, within the same time-frame, the Joint Economic Committee submits its recommendations as to appropriate fiscal policies related to the goals of the Employment Act of 1946, and the Joint Commitee on Internal Revenue Taxation gives its views and estimates relative to tax legislation.

The March 15 deadline compels the committees to project their estimates and expectations before they have had time to conduct hearings and review program details, and to make judgments on amounts to be authorized or appropriated. In consequence, these committees have an incentive to inflate their estimates, so that it will be easier to stay within the budget ceiling and allocations subsequently determined.

The Committees on the Budget, for their part, cannot recommend ceilings too far below the aggregate of the estimates of the other committees, lest their decision be challenged and drastically modified in floor action. Whatever the expectations of conservative-minded members that budget ceilings would be a driving force for economy in federal expenditures, the Committees on the Budget have to be realistic in their assessment of the temper of the Congress and the forces which can be mobilized against them. They are superimposed on the existing committee structure and have no legislative power of their own, only the leverage on internal discipline that a concurrent resolution can confer.

In that sense, they will not be able to match the power and influence exercised by the standing committees, which determine what programs will be authorized and what funds actually will be appropriated.

Nevertheless, the budget ceilings and related procedural disciplines of the Congressional Budget and Impoundment Control Act are forcing the authorization and appropriations committees to change their ways. They must get their work done by specified dates. They are limited in their policy and program judgments by the budget ceilings and allocations that are imposed. In the process, new tensions arise and supplant some of the old ones. The authorizing and funding committees resent as competitors the budget committees which, in order to make intelligent judgments about spending levels, are propelled into program reviews and evaluations. The budget committees have their own staffs and are supported by the Congressional Budget Office. Together, these staffs comprise a substantial new component of the Congressional bureauracy.

C. Congressional Staff and Support Agencies

The Congress is not only a House and Senate and an assortment of committees, it is a big sprawling bureaucracy of staff employed directly by members and committees or working in Congressional support agencies. Additionally, large numbers are employed in administrative and housekeeping chores for the Congress. Altogether the Congress and its support agencies employ probably more than 30,000 persons.

1. Congressional Committee Staff

In the Congressional bureaucracy, the committee staffs have a critical role. They conduct investigations, gather information, organize hearings, select witnesses, develop policy issues, prepare reports, and work closely with the chairmen and committee members in moving legislation through the Congress. The difference in composition in the two houses – 435 House members and 100 Senators – with a rough equivalence of workload, means that each Senator must spread his time and attention among more committees and subcommittees, and therefore, he depends more heavily on staff assistance than does a Representative. It is not uncommon in floor debate for 20 or 30 or more staff members, both from the Senators' own offices and from committees, to have access to the floor on a complex bill. In the House, only 4 or 5 committee staff members are allowed access to the floor during a legislative debate.

In former years, committees of Congress typically would have a clerk and one or two assistant clerks. The Legislative Reorganization Act of 1946 introduced the concept of a professional staff to be appointed solely on the basis of qualifications. Each standing committee was authorized four professional and up to six clerical staff. The Legislative Reorganization Act of 1970 authorized two more professionals and

provided that part of the professional and clerical staff would be allocated to the minority (Republican) members of the committee. In 1975 the House, acting unilaterally, increased the professional staff to 18, and the clerical staff to 12, for each standing committee.

These official numbers are by no means indicative of the size of committee staffs. They refer only to the full committees and not to the subcommittees. As committee workloads grew, and more and more subcommittees were created, the small number of staff authorized for full committees was supplemented by varying numbers of staff persons, usually authorized in yearly expense resolutions for committees and attached to subcommittees. Numbers employed on each committee range widely from a few to a few hundred, depending on the committee's importance, subcommittee organization, and workload. Total staff employed by House and Senate committees and joint committees probably exceed 3,000.

Congressional committee staffs, for the most part, are hired and fired by committee chairmen or staff heads acting for the chairman. There is no tenure and no formal job and salary classification. Ceilings are placed on top staff salaries which are equivalent to those in the classified civil service. Job titles vary, but most committees have a staff director and/or a chief counsel. In some cases the two jobs are combined. Other staff will be designated according to some speciality, such as science consultant or economic consultant.

A professional staff career in the Congress depends largely on the tenure and longevity of the chairman and the fortunes of the party majority. If a chairman dies, is defeated, or retires, changes in the top staff usually are made. Also, if the party majority changes, there is substantial turnover among the professional staff. The continuity in Democratic control of the Congress – for 42 of the past 46 years – has diminished the risk of wholesale staff changes.

2. *Congressional Office Staff*

Members of Congress may call upon committee staffs for advice and assistance, but for general legislative duties and office operations, each member has his or her own staff. Numbers vary in individual offices. Senators employ on the average more than 20, and in a few cases as many as 50 individuals. House members employ between 10 and 18. Most members of Congress deploy part of their staff in field offices in their State or district. Office staffs total possibly 9,000 for all Senators and Representatives.

Each Congressional office will have the usual complement of secretaries, possibly an office manager, a legislative assistant, a press aide, a research assistant, and at the top an administrative assistant or A.A., who is in charge of the office staff. The A.A. is a very important functionary. He works in a very close and confidential relationship with the elected member, assisting in political as well as legislative duties. Not

Table 37. Fiscal Year 1976, Full-Time Positions or the Equivalent Devoted to Congressional Work

Agency	Professional	Other	Total
GAO (Congress, 30 percent)	1,267	380	1,647
CRS	603	178	781
CBO	135	58	193
OTA	64	29	93

Source: Ernest S. Griffith, "Four Agency Comparative Study," in *A Compilation of Papers on Congressional Support Agencies*, prepared for the Commission on the Operation of the Senate, Committee Print, 94th Cong., 2d sess., 1976, p. 107.

infrequently the A.A. sees his job as a training ground for a political career on his own and runs for office when his member withdraws.

3. Congressional Support Agencies

Committees and members of Congress can get professional assistance from Congressional support agencies. These include the Congressional Research Service (CRS), the General Accounting Office (GAO), the Office of Technology Assessment (OTA), and the Congressional Budget Office (CBO). According to a study by Dr. Ernest S. Griffith for the Commission on the Operation of the Senate, these agencies in FY 1976 had the equivalent of about 2,700 employees doing work for Congress, as shown in Table 37. The GAO has many more employees (about 5,500) than are shown in the table because it performs a variety of administrative and other services not directly tied to Congress. In the paragraphs which follow, we comment briefly on these four support agencies because collectively they are an important resource upon which Congress draws for information and analysis.

a. Congressional Research Service (CRS)

The CRS is a component of the Library of Congress. It was preceded by the Legislative Reference Service (LRS), which the Library established in 1914 to provide such services as indexing, digesting, and compiling laws and which, through the years, provided additional information services to the Congress. The Legislative Reorganization Act of 1946 elevated the status of the LRS by giving it positive legislative recognition and a role in policy analysis for the Congress. In addition to its usual services in indexing, digesting, compiling and summarizing, the LRS was to assist committees in analyzing and evaluating legislative bills or recommendations by the Executive Branch for legislative action.

The Legislative Reorganization Act of 1970 continued the upgrading process. The LRS was redesignated the CRS. It gained autonomy within the Library setting, higher pay for the Director, and authority to contract for research and other services in specialized fields. It was to

provide information and analysis which would help committees (i) determine whether proposals should be enacted; (ii) estimate the probable results of such proposals and alternatives; and (iii) evaluate alternative methods for achieving those results. The CRS was to keep Congress advised of programs about to terminate and to make lists of program areas that could profitably be analyzed. When performing work of the committees, the CRS was authorized, with the committee's permission, and as its "agent," to request documentary information from executive agencies, who were directed to comply with such requests.

The CRS provides a great deal of information and analysis to the Congress on scientific and technical matters. For many years it has maintained a roster of senior specialists for counseling services; the first senior specialist for science and technology was appointed soon after the National Aeronautics and Space Act became law in 1958. The Legislative Reorganization Act of 1970 authorized specialists and senior specialists in 23 broad fields, including science, technology, and engineering and public works.

During the early 1960's, when there was a flurry of interest in legislation to create a Congressional Office of Science and Technology as a counterpart to the one in the Executive Branch, or otherwise to provide Congress with scientific advisory or counseling services, an immediate consequence was Congressional support for a Science Policy Division in the CRS. Organized in 1964, that division, which employs about 45 professionals, makes technical studies or gathers information on technical subjects in response to requests by members and committees of the Congress. Other divisions of the CRS, such as Energy and Environment, also are called upon to supply technical information. Members of the staff of the Science Policy and other divisions often work very closely with committee staffs, and may be detailed to the committees for varying periods of time.

CRS has been both praised and criticized as a Congressional support agency. Much of its time and resources is devoted to gathering information in response to Congressional requests in behalf of constituents or to answer questions that come up in the course of legislative business. CRS has been characterized in a recent study as "in transition from being an organization preoccupied with legislative reference services to becoming a policy analysis and research arm of the Congress."[1] To make more progress in this transition, the study recommends that the CRS improve its capabilities for interdisciplinary research, devote more resources to developing methodologies for policy analysis, conduct more original and empirical research in executive operations, expand its contracting powers to bring in needed expertise, and establish more effective relationships with other research centers and organizations.

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[1] James D. Carroll, "Policy Analysis for Congress: A Review of the Congressional Research Service," in *A Compilation of Papers on Congressional Support Agencies*, prepared for the Commission on the Operation of the Senate, Committee Print, 94th Cong., 2d sess., 1976, p. 4.

As a component of the Library of Congress, the CRS has the benefit of rich documentary resources but also the handicaps of library-oriented research and hurried responses to infinitely varied Congressional demands. It provides useful background material, issue papers, and makes important special studies, but it lacks the mobility and muscularity of an investigative agency which can knock on agency doors and look into agency files to develop information and issues for Congress. This is more suitably a function of the GAO.

b. General Accounting Office (GAO)

The Budget and Accounting Act of 1921, which established the national budget system, created two agencies to pursue economy and efficiency goals in the government: the Bureau of the Budget as the President's agency for budget-making and management guidance in the Executive Branch; and the General Accounting Office as an independent (later designated a Congressional) agency for investigating "all matters relating to the receipt, disbursement and application of public funds." The Comptroller General, as the head of the GAO, was directed to make investigations and reports as ordered by either house of Congress or by any committee having jurisdiction over revenues, appropriations or expenditures. At the request of these committees, he was to furnish staff assistance and information. A particular obligation of the Comptroller General was to report to the Congress every expenditure or contract made by any department or agency in violation of law.

Twenty-five years later, when the Legislative Reorganization Act of 1946 was enacted, the GAO received a new mandate, "to make an expenditure analysis of each agency in the executive branch . . . which . . . will enable Congress to determine whether public funds have been economically and efficiently administered and expended." Reports of such analysis were to be submitted to the committees dealing with appropriations and expenditures as well as to legislative committees of jurisdiction. This mandate, if literally executed, would have been rather costly and time-consuming, but it would have insured systematic review of agency activities in behalf of the Congress. Sufficient funds for the purposes of that provision never were appropriated, and it remained a silent authority on the statute books.

The Budget and Accounting Procedures Act of 1950 expanded the Comptroller General's responsibilities under the enabling legislation of 1921. He was charged with prescribing and monitoring accounting systems for the executive agencies and auditing, "as an agent of the Congress," agency accounts and financial transactions to insure accord with specified purposes, laws and regulations.

The GAO's mission to insure economy and efficiency and legality of expenditures was perceptibly broadened after the Economic Opportunity Act amendments of 1967, which directed the GAO to make an investigation of Office of Economic Opportunity programs and activities and assess not only their administrative efficiency but the extent to

which statutory objectives were being achieved. This was the GAO's first explicit statute for program evaluation. That mandate was generalized in the Legislative Reorganization Act of 1970, which authorized the Comptroller General to "review and analyze results of Government programs carried on under existing law, including the making of cost-benefit studies." The reviews, analyses, and studies were to be made on the Comptroller General's own initiative, or as ordered by either house, or upon committee request. A staff of experts was to be developed in the GAO and made available to assist committees in analyzing cost-benefit studies or in conducting their own studies.

Title VII of the Congressional Budget and Impoundment Control Act of 1974 amplified the Comptroller General's responsibilities in program evaluation. He was directed to review and evaluate the results of government programs and activities conducted under existing law, either upon his own initiative, or upon request by the House or Senate or committees having jurisdiction over such programs and activities. Also, the Comptroller General was to assist committees, when requested, in developing legislative statements of objectives and goals so that program evaluation could be better performed. For these purposes, the Comptroller General was authorized to establish an Office of Program Review and Evaluation within the GAO and to employ additional experts.

The GAO does not confine its work for the Congress to program evaluation in a specialized technical sense. It makes surveys and investigations in any aspect of governmental affairs upon request of committees and members of Congress, and upon its own initiative in anticipation of such requests. In contrast to the other support agencies, the GAO has a network of field offices at home and abroad, statutory access to files of government agencies and contractors, and powerful leverage over agency performance by virtue of the Comptroller General's authority to pass upon the legality of government expenditures.

The term "management audit" frequently is used by the GAO to describe its reviews and evaluations of agency programs and activities. Hundreds of reports are sent to the Congress each year, and under existing law, agencies must report to the Congress within 60 days their responses to recommendations affecting them made in reports by the Comptroller General.

Many GAO investigations are concerned with technical programs of the federal government. Hesitant in past years to get involved in highly technical areas, the GAO now calls upon experts for consulting services and employs staff with varied technical training. The Science and Technology Subdivision of the Procurement and Systems Acquisition Division is a GAO center for technical surveys and reports to the Congress, although other divisions also contribute.

Reform of the budget structure is a continuing responsibility of the GAO under the Legislative Reorganization Act of 1970 and the Congressional Budget and Impoundment Control Act of 1974. Working with the

Secretary of the Treasury, the Director of OMB and the Director of CBO, the Comptroller General is required to "develop, establish, maintain and publish standard terminology, definitions, classifications and codes for Federal fiscal, budgetary, and program-related information." Studies to date have convinced the GAO that the functional categories in the President's budget do not provide a good enough framework for Congressional decisions and should be reworked to provide more detailed and coherent information about agency programs.

Also, the GAO is mindful that the Congressional Budget Act requires that, commencing in FY 1979, the President's budget be presented in terms of national needs, agency missions, and basic programs. This requirement, which stemmed from several recommendations in the report of the Commission on Government Procurement, led the GAO to undertake two projects relating specifically to R&D information: (i) a classification structure was developed to enable the Congress to get a total view of R&D funding, which cuts across agency lines; and (ii) the feasibility of a "mission" approach to funding for federal R&D is being studied. The R&D classification structure has not, as yet, met with enthusiastic approval by the Office of Management and Budget, and its applicability is still to be determined.

c. Office of Technology Assessment (OTA)

In the 1960's, technology issues pressed upon Congress—the environment, energy, food, transportation, drug abuse, medical care—a host of baffling, intricate and finely interwoven problems. The Executive Branch was the fount and repository of much of the basic information needed for Legislative decisions, but at times the information was withheld, or if made available, was mistrusted. Increasingly, sentiment was expressed in the Congress that it should have its own resources for scientific advice free from Executive Branch or contractor bias.

This sentiment was harnessed by the House Committee on Science and Astronautics (now Science and Technology), which had been crusading, at least since 1967, for a technology assessment mechanism that the Congress could call its own. Representative Emilio Q. Daddario, who chaired a Subcommittee on Science, Research, and Development, was the most persistent advocate of this cause. His efforts culminated in the Technology Assessment Act of 1972, although by this time he was no longer in Congress. He came back to head the new office created by the act.

The law provides for an Office of Technology Assessment to develop objective, timely, and adequate information on potential impacts of technological applications—an early warning approach—to be used in assessing legislation before the Congress. The OTA comprises a Technology Assessment Board and a Director, assisted by a Technology Assessment Advisory Council. The 13-member Board—six Senators and six Representatives plus the Director as a nonvoting member, sets policies, which are executed by the Director. The Director is appointed for a

6-year term. The 12-member Council has 10 public members plus the Comptroller General and the CRS Director. The GAO and the CRS are required to furnish support services.

The Technology Assessment Board was conceived, in the first instance, to be an organization of Congressional and public members, the latter providing scientific background and expertise. A House floor amendment by Representative Jack Brooks confined the membership of the Board to legislators, except for the Director. The Advisory Council was added to afford some means of public member participation.

In the short period of its working experience, the OTA has sponsored some useful technical studies and tapped the scientific community for consultation and advice on problems of interest to several committees of the Congress. But it is not widely known in the Congress, and it has hardly become the Congressional center of science and technology that so many expected. It works with the handicaps of a mission not too well defined, limited budget resources, heavy dependence on contractors for technical studies, and limited capability for rapid response to Congressional demands. It also has to contend with problems of politics and patronage in staffing and deficiencies in internal administration.

OTA's dilemma is that to survive and grow it must gain broader Congressional acceptance, and the price of doing that is to retreat from, if not to abandon, the grander concept of a Congressional center for sophisticated analyses of technology's longer-range consequences. Most of OTA's studies to date have been inspired by members of its own Board or by the Director himself. To accommodate the diverse and urgent necessities of the legislative process, the OTA will have to transform itself into a rapid-response technical service agency. It will then find common ground with the Science Policy Division of the CRS.

d. Congressional Budget Office (CBO)

The Congressional Budget Office supports the Committees on the Budget in performing the procedural routines prescribed by the Congressional Budget and Impoundment Control Act of 1974. The Director, appointed by the presiding officers of the House and Senate, serves for a 4-year term. The CBO is authorized to obtain information from executive agencies and to utilize their services, facilities and personnel, with or without reimbursement. Such assistance also may be obtained from the GAO, the CRS, and the OTA.

Although the CBO's primary allegiance and obligation are to the Committees on the Budget, it may provide information and advice to the tax and appropriations committees, other committees and joint committees, and individual members, in decreasing order of priority. Temporary details of CBO's staff also may be made to Committees on the Budget and other committees.

The two most important functions of the CBO are to (i) develop for the Congress alternative fiscal policies, and (ii) keep score on committee bills providing new budget authority. Under the law, the CBO Director

must submit to the Committees on the Budget in the House and Senate by April 1 a report on fiscal policy for the coming fiscal year. The report is to present, among other things, alternative levels of total revenues, total new budget authority and total outlays, including related surpluses and deficits. The report also is to include a discussion of national budget priorities and alternative ways of allocating funds among major programs or budget or functional categories, to meet major national needs and achieve balanced growth and development. The CBO also is charged with issuing a report at or near the beginning of each fiscal year, projecting for each of the next 5 fiscal years total budget authority, outlays, and revenues.

Scorekeeping and related technical chores, such as providing to the committees cost estimates on legislation to be reported, will constitute a continuing, heavy workload for the CBO. It will undoubtedly strive, nevertheless, to surmount the "arithmetic" and maintain a stance as a Congressional center for policy and program analysis in areas of evident fiscal impact. It should not be expected to become a Congressional agency for detailed budget-making, which is essentially an executive task. Its primary role will be to arm Congress with information to understand better what the President proposes, and what, in broad terms, are alternative courses of action.

e. Outlook for Support Agencies

Recent evaluations of the Congressional support agencies show two major concerns: overlap and duplication in the services they perform for the Congress, and deficiencies which handicap their growth and ability to perform such services in a competent way. In the matter of duplication, proposals have been made to assimilate the support agencies in a broader Institute for the Congress, or to establish a Coordinator of Research working with a Research Coordinating Council to select task forces from the support agencies for performing studies requested by the Congress.[1] Considerable duplication in services by the support agencies is evident. Some of it can be eliminated by better coordination, but much of it is inevitable, since committees and members of Congress want to choose their own sources, particularly since the support agencies differ in authorities, capacities, resources, and style of work.

As for growth prospects, little can be expected in the next 5 years. The Congress, having crossed the billion-dollar threshold in its own yearly expenditures, is very sensitive to requests for budget increases from its support agencies. New needs may emerge, and new tasks of overriding importance may be placed upon these agencies, but the prospects in the years immediately ahead are for doing more with what they have.

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[1] James D. Carroll and Ernest S. Griffith, in *A Compilation of Papers on Congressional Support Agencies* prepared for the Commission on the Operation of the Senate, Committee Print, 94th Cong., 2d sess., 1976, pp. 4, 95.

Questions and Issues

Many significant questions and issues are suggested or implicit in Mr. Roback's incisive discussion. With his discussion in mind, we shall list in agenda-like form six sets of questions covering what appear to be the most important issues with respect to Congress, issues that should be given thoughtful attention by the scientific and technical community and all those, in Congress and elsewhere, who are concerned with how Congress deals with R&D.

(1) *Transition and Recent Developments.* How will the transition from the Ford to the Carter administration affect the treatment of R&D in the Congress? Will there be a greater inclination to support the President's budget now that the Presidency and Congress are controlled by the same party? What will be the effects of the new committee and subcommittee structures relating to R&D in the Senate and House?

(2) *Congressional Review of R&D.* In what degree of detail should Congress attempt to review R&D programs? What degree of detail is feasible from a practical standpoint? Should Congress attempt to develop review capabilities for R&D that are equivalent in quality and capacity to those available to agency heads and the President? Should this be done through additional committee staffing or consultants, or through increased reliance on OTA, GAO, CRS or other support agencies? What principles should guide the determination of the size of Congressional staffs dealing with R&D?

(3) *Congressional Control of R&D.* What degree of control should Congress seek to exercise over federal R&D programs? Should Congressional controls be legally binding, informally binding, or advisory? What controls, such as program clearances or reprogramming approvals, can properly be exercised by committees as distinct from Congress as a whole? How should the boundaries of Legislative and Executive rights and responsibilities be defined? When does legislative oversight become executive management?

(4) *Need for the Double Look.* How essential is the current practice of annual R&D budget reviews by both authorization and appropriations committees? How do the values, such as providing additional checks and balances, compare to the losses, such as the extra burdens of a double review on both Congressional and Executive agencies? Should consideration be given to longer term—say 5-year—authorizations for R&D programs to reduce the annual review burden, permit more attention to in-depth evaluation, and perhaps tie in with the pattern proposed in pending "sunset legislation"?

(5) *Public Participation.* What forms of and occasions for public participation in Congressional actions in R&D are most useful to Congress? Most effective in affecting Congressional decisions? What are the do's and don'ts for scientists and scientific and technical organizations to observe in their dealings with Congress?

(6) *Expectations vs. Reasonable Possibilities.* Just what should the public expect of Congress? In what respects should Congress try to be coequal to the Executive Branch? In what respects can it be? Can 435 Congressmen and 100 Senators do effectively all that is now expected of Congress? As Congress becomes increasingly overloaded, should staff and support agencies be further expanded? Should greater reliance be placed on the Executive Branch? Or should expectations be cut back to reasonable possibilities?

Appendix

Additional Crosscuts of Support for R&D

The tables below provide additional statistical information on the past distribution of funds for R&D. They do not include data on current R&D budgets, since NSF's detailed analyses of the FY 1978 budget will not be available until later in 1977. It should be noted that the tables are

Table A-1. Basic Research by Field of Science: Data Classified as in FY 1977 Budget (Obligations in millions)

	FY 1967	FY 1971	FY 1975
Current dollars:			
Life Sciences	$ 573	$ 570	$ 776
Psychology	60	48	48
Physical Sciences	605	582	616
Environmental Sciences	209	280	331
Mathematics	65	51	59
Engineering	156	169	228
Social Sciences	57	70	73
Other Sciences	4	9	15
TOTAL	$1,728	$1,779	$2,146
Constant 1972 dollars:			
Life Sciences	$ 717	$ 596	$ 622
Psychology	75	50	38
Physical Sciences	757	609	494
Environmental Sciences	262	293	265
Mathematics	81	53	47
Engineering	195	177	183
Social Sciences	71	73	59
Other Sciences	5	9	12
TOTAL	$2,163	$1,860	$1,720

Source: Current dollar figures are from *Federal Funds for Research, Development, and Other Scientific Activities*, Volume XXV, NSF.

based on obligations, and therefore do not correspond to the budget authority and outlay figures used in most of the tables in Chapter 3 of the report. They may be useful for reference, however, and to corroborate many of the statements in the text.

Tables A–1 and A–2 show obligations for basic and applied research by field of science for selected years from FY 1967 to FY 1975, the most recent year for which actual data are available. In constant dollars, the totals show a decrease in basic research of about 20 percent and a small increase in applied research. Environmental Sciences is the only field in basic research that is supported at a higher "real" level in FY 1975 than in FY 1967, although it has shown a decrease since FY 1971. On the other hand, support for basic research in engineering and the life sciences has increased since FY 1971, but is still below the FY 1967 levels. In applied research, life sciences, psychology, environmental sciences, and social sciences all show increases in constant dollars over the entire period, but only life sciences has shown an increase over the FY 1971 level.

The distribution of federal R&D funds among types of performers of R&D is shown in Table A–3. The amounts under "Federal Intramural" include funds for administration and management of the entire program as well as for technical work done by the federal government in

Table A–2. Applied Research by Field of Science: Data Classified as in FY 1977 Budget (Obligations in millions)

	FY 1967	FY 1971	FY 1975
Current dollars:			
Life Sciences	$ 830	$1,066	$1,674
Psychology	48	67	85
Physical Sciences	355	292	409
Environmental Sciences	173	247	322
Mathematics	65	68	78
Engineering	1,271	1,655	1,813
Social Sciences	131	234	231
Other Sciences	92	91	172
TOTAL	$2,965	$3,720	$4,783
Constant 1972 dollars:			
Life Sciences	$1,039	$1,115	$1,342
Psychology	60	70	68
Physical Sciences	444	305	328
Environmental Sciences	217	258	258
Mathematics	81	71	63
Engineering	1,591	1,731	1,453
Social Sciences	164	245	185
Other Sciences	115	95	138
TOTAL	$3,711	$3,890	$3,835

Source: Current dollar figures are from *Federal Funds for Research, Development, and Other Scientific Activities*, Volume XXV, NSF.

Table A-3. Conduct of R&D by Type of Performer (Obligations in millions)

	FY 1967 Actual	FY 1971 Actual	FY 1975 Actual	FY 1976 Est.
Current dollars:				
Federal Intramural	$ 3,396	$ 4,156	$ 5,395	$ 5,923
Industrial Firms	10,262	8,135	9,114	10,776
Universities & Colleges*	1,454	1,644	2,495	2,569
Federal R&D Centers Administered by Universities	666	729	935	1,065
Other Nonprofit Institutions	624	696	938	973
All Other	127	204	260	318
TOTAL	$16,529	$15,564	$19,044	$21,625
Constant 1972 dollars:				
Federal Intramural	$ 4,252	$ 4,347	$ 4,324	$ 4,494
Industrial Firms	12,848	8,509	7,305	8,177
Universities & Colleges	1,820	1,720	1,926	1,949
Federal R&D Centers Administered by Universities	834	765	749	808
Other Nonprofit Institutions	781	728	752	738
All Other	159	213	208	241
TOTAL	$20,694	$16,280	$15,264	$16,407

Source: Current dollar figures are from *Federal Funds for Research, Development, and Other Scientific Activities*, Volume XXV, NSF.
* More recent data for this sector are shown in Table 12, Chapter 3.

Table A-4. Estimated Total National Pattern of R&D Funding: FY 1976 (in billions)

Performers of R&D	Sources of Funds				
	Federal Government	Industry	Universities & Colleges	Other Nonprofit	All Sources
Federal Government	$ 5.9	–	–	–	$ 5.9
Industry	10.8	$16.3	–	–	27.1
Universities & Colleges	2.6	.1	$ .8	$ .3	3.8
Federal R&D Centers Administered by Universities	1.1	–	–	–	1.1
Other Nonprofit Institutions and All Other	1.3	.1	–	.3	1.7
TOTAL, by source of funds	$21.7	$16.5	$ .8	$ .6	$39.6

Source: *National Patterns of R&D Resources*, 1953-1976, NSF. The figures for the federal government as a source of funds are adjusted to correspond with Table A-3.

its own laboratories and other installations. The trends in constant dollars, from FY 1967 to 1975 show increases for federal intramural and colleges and universities but a large decrease for industry. All sectors except nonprofit institutions are estimated to increase in FY 1976.

Table A–4 shows the relationship between the sponsors and performers of all R&D carried out in this country as estimated for FY 1976. The estimates indicate that the federal government supports 55 percent and industry 42 percent of the total national R&D effort. Industry is by far the largest performer, carrying out 68 percent of the total; the federal government performs 15 percent, and universities and colleges 10 percent. About 40 percent of industry's work is supported by the federal government.

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